BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAH-668	2. SUBJECT CLASSIFICATION (695) AP12-0000-G580

3. TITLE AND SUBTITLE (240)
Irrigated agriculture in Afghanistan

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)
Experience, Inc.

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1978	134p.	AF631.7.E96

9. REFERENCE ORGANIZATION (130)
Experience

10. SUPPLEMENTARY NOTES (500)

11. ABSTRACT (950)

12. DESCRIPTORS (920)		13. PROJECT NUMBER (150)	
Irrigation	Constraints	298035300	
Ground water	Soil management	14. CONTRACT NO.(140)	15. CONTRACT TYPE
Water management	Land development	AID/afr-C-1130	GTS
Water use		16. TYPE OF DOCUMENT (160)	
Irrigated land			
Afghanistan			

AID 590-7 (10-73)

PN-AAH-66?

PREPARED FOR:
THE AGENCY FOR INTERNATIONAL DEVELOPMENT
UNDER CONTRACT NO. AID-AFR-C-1130
W.O. # 94

IRRIGATED AGRICULTURE IN AFGHANISTAN

DECEMBER 1978

EXPERIENCE, INCORPORATED
MINNEAPOLIS MINNESOTA 55402

PREPARED FOR:
THE AGENCY FOR INTERNATIONAL DEVELOPMENT
UNDER CONTRACT NO. AID-AFR-C-1130
W.O. # 94

IRRIGATED AGRICULTURE IN AFGHANISTAN

DECEMBER 1978

EXPERIENCE, INCORPORATED
Counsel to Decision Makers *EXPERIENCE*-Agriculture/Agribusiness*
1725 K STREET N.W., SUITE 312 WASHINGTON, D.C. 20006 U.S.A. (202) 659-3864

December 1978

Mr. Fred Marti
NE/TECH/AD
Agency for International Development
Washington DC 20523

Subject: Contract AID/afr-C-1130, Work Order No.94.

Dear Mr. Marti:

We are pleased to transmit to you copies of our report titled Irrigated Agriculture In Afghanistan, which reflects the analyses called for in the subject Work Order. This report identifies the principal problems and constraints affecting irrigated agriculture in Afghanistan, describes possible solutions to these problem areas, and presents groupings of these solutions in 'technical packages' we believe suitable for incorporation into future Project Identification Documents. As such, the recommendations in Section II. are of a broad nature and have nationwide relevancy.

We would like to add to the Acknowledgements expressed in this Report our thanks to AID/W and USAID/Afghanistan staff who measurably assisted us in this undertaking.

Sincerely,

Carl F van Haeften

Carl F. van Haeften
Project Administrator

/pf

TABLE OF CONTENTS

ANNEXES

II. RECOMMENDATIONS

1. Investigate ground water potential of both deep and shallow wells.

2. Rehabilitate the small scale irrigation systems for improving water control throughout the complete system.

3. Introduce improved crop husbandry based on crop water use efficiencies and water management practices on the farm.

4. Initiate land improvement work, including on-farm infrastructure, to improve on-farm water management.

5. Begin water and related land resource inventories to provide data for planning and designing irrigation projects.

III. INTRODUCTION TO THE REPORT

A. Scope and Authorization

This Study, implemented jointly by a team of engineering and agricultural specialists from Experience, Incorporated (the Contractor), and a group of technical specialists from the Agency for International Development's Mission to Afghanistan (USAID/Afghanistan), has comprised an intensive review, during a two-month period, of past and present developments in irrigated agriculture within the Democratic Republic of Afghanistan (DRA). The Study has measurably benefited from review by, discussions with, and contributions from DRA officials of Ministries and Departments concerned with such irrigated agricultural developments. DRA officials also joined members of the Contractor's team and USAID technicians in visiting and inspecting irrigation systems in many parts of Afghanistan.

The participation of the Contractor's team was authorized by Contract No. AID/afr-C-1130, dated 29 September 1978. (Work Order No. 94)

B. Objective of the Study

The objective of the Study, as stated in Article II of the Work Order is to identify and recommend for further investigation new procedures and technologies that could lead to an increase in the availability and the efficient use of water for agricultural production in ways appropriate to the

poorer farmers.

C. Purpose of the Report

This Report summarizes the findings of the reviews and investigations made during the Study. It has been divided into the following Sections:

- Determination of problems and constraints currently hampering or capable of imposing future limitations on the development of irrigated agriculture;

- Description of possible alternative solutions responsive to the aforementioned problems and constraints;

- Formulation of "technical packages" through the selective combination of possible solutions;

- Identification for future reference of certain unevaluated constraints which were outside the purview of the present Report.

D. Methodology

Details of the methodology employed in this assessment of irrigated agriculture in Afghanistan are presented in Annex 4.

E. Acknowledgements

The Contractor's efforts in the implementation of this Study and the preparation of the Report were substantially helped and benefited by the considerable assistance, support, and factual inputs from USAID, specifi-

cally from the offices of the Deputy Director, Agriculture, and Program.

Further help, of very significant value, was provided by DRA officials and staff of Ministries and other departments and agencies concerned with irrigated agriculture in Afghanistan. The gratitude of the Contractor is particularly extended to the following for their contributions to this Study:

<u>Ministry of Planning</u>

Mr. Fateh Mohamad Tarin	- Deputy Minister
Dr. Usman Akram	- General Director, Agriculture and Irrigation
Mr. Jafar Kazem	- President, Foreign Relations Department

<u>Ministry of Agriculture and Land Reform</u>

Mr. Abdul Ahad Sarsam	- Deputy Minister
Mr. Mohamed Hasan Paiman	- President of Extension
Mr. Jan Mohamed	- President Evaluation, Extension Department
Mr. Feda Mohamed Hashimi	- Staff Member, Extension Department

<u>Ministry of Water and Power</u>

Mr. Nassim Azimi	- President, Planning
Mr. Mohamed Ali	- Staff Member, Planning
Mr. Farouq	- Staff Member, Planning

<u>Rural Development Department</u>

Mr. Sulemanzai	- President
Mr. Hekmatullah	- Vice President
Mr. Sayed Akbar	- General Director, Irrigation

<u>Agriculture Development Bank</u>

Mr. Abdul Tawab Asefi	- President
Mr. Sayed Abdul Rahman Hashimi	- General Director, Credit

IV. PROBLEMS AND CONSTRAINTS

A. Introduction

The identification of major problems and constraints inhibiting the development of irrigated agriculture was achieved through three stages:

A farm model irrigation supply system was synthesized in a step-by-step process from the individual farmer's plot, through the several components of the system, to the ultimate source of the irrigation water supply. From this the key variables were identified, and through consideration of these dependent variables and the respective causal relationships involved, problem areas and constraints within the basic supply system were highlighted.

An effective demand structure with corresponding dependent variables to complement the above supply system was then established. This in turn led to a preliminary listing of problem areas and constraints for each of the key variables in the effective demand structure.

Through re-examination of the various problems and constraints, cross-critiquing, and extensive discussion among the Contractor-USAID-DRA participants, the major variables surfaced and were placed in order of priority, lesser variables were relegated to minor positions or eliminated, and the principal problem areas and constraints were established around which possible solutions and "technical packages" were later

developed.

A more detailed description of the development of the three stages follows.

1. Elements of a Representative Irrigated Agricultural (supply) System.

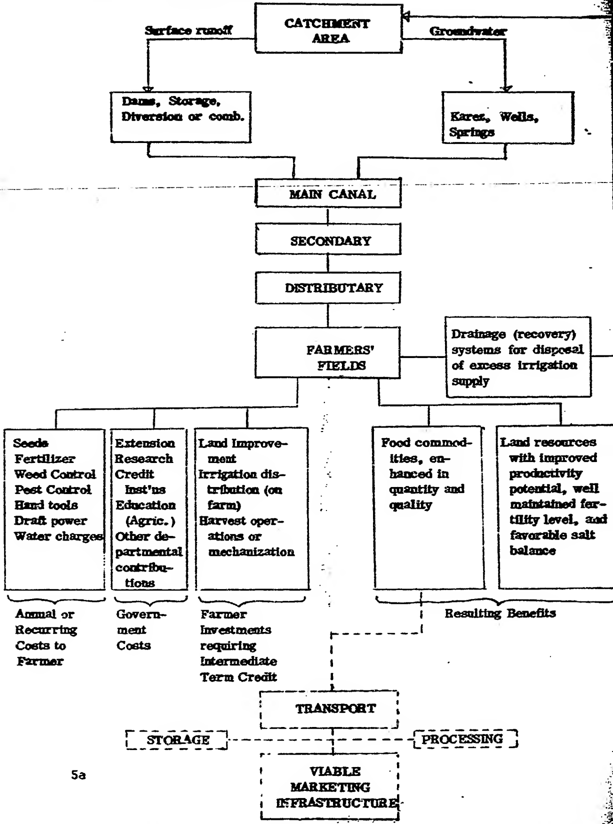
The diagram in Figure I-1 comprehensively lists in matrix form the principal components of a representative irrigated agricultural system.

The catchment area is the source from which irrigation water is derived. Human intervention in the form of diversions, either from surface or from groundwater sources, captures a supply of water from the resource area. This in turn flows through a network or partial network of conveyance facilities to farmers' fields. Optimal withdrawals from the resource area together with the performance characteristics of the conveyance system are major determinants in supplying adequate deliveries of water to farmers' fields.

A favorable environment for growing plants usually required, in addition to appropriate water or moisture availability, some kind of drainage relief system for the disposal of excess water. This obviates soil saturation and thus ensures the accessibility of aerobic bacteria and plant roots to sufficient amounts of oxygen.

Appropriate farm infrastructure, including well-graded fields permitting a uniform application of water; efficient inter-field distribution

Fig. I - 1 Representative Irrigated Agricultural System



systems; well-developed soil profiles; and perhaps some mechanization to permit more timely farming practices to be applied, requires investment by the farmer. To effect this, intermediate or long-term credit is usually needed.

The farmer also needs technical assistance in establishing appropriate infrastructure on the farm. This frequently takes the form of advice and counsel on more modern agricultural practices, especially water management, in order to obtain improved yield levels. Certain institutional needs, which are normally supplied at government cost, are concerned with his access to credit, agricultural schools, and research stations, as well as other governmental service organizations.

Farmers are also faced with costs which are annual, recurring, or which vary according to the cropping cycle. These comprise good quality seeds; fertilizer and other agricultural chemicals; tools; maintenance of power, whether machine fuel or feed for animals; and in most countries, water charges. Small-scale farmers usually require short-term production credit for amortizing these costs.

Finally, local supporting enterprises are needed to handle the harvested crop. Basic elements of the crop-handling support system are shown as transport, storage, processing (where required), and marketing.

2. <u>Analysis of User-demand Relationships.</u>

The starting point for this analysis was arbitrarily taken as the individual farmer's plot, and the key variables, as well as the respective factors which contributed to them, were then developed: first for the supply system, and then for the complementary effective demand. Following interfacing and discussion with DRA officials, the supply and demand systems were refined and the most significant variables arranged in order of importance. Table I-1 shows the components of these two on-farm irrigation systems and indicates the causal relationships that are considered to exist and to affect irrigated agricultural practices in Afghanistan. These conditions are described in the following paragraphs of this Section, each keyed to the respective key variable.

B. SUPPLY SYSTEM PROBLEMS

1. Resources

There is insufficient knowledge concerning the extent and quality of the country's water resources. In the case of streamflow, for example, the number of gaging stations is about 80 percent of the total recommended by the U.S. Geological Survey about 12 years ago; data quality, however, is not commensurate, as there are considerable data that are classified as only fair to poor; and there have apparently been a number of cases where shifting controls have affected rating curves. Moreover, reduced budget allocations have been responsible for shortfalls in actual departmen-

Table I - 1 Components of Representative On-Farm Irrigation System

KEY VARIABLES

- ON-FARM IRRIGATION
  - SUPPLY SYSTEM
    - RESOURCES
      - Management
        - Exploitation
          - Failure to Intercept
          - Failure to Optimize
        - Conservation
      - Inventory
      - Technology
    - HYDRAULIC DESIGN
      - Right of Way
      - Land Configuration
      - State of Technology
      - Lack of Hydrology Data
      - Conveyance System
      - Budget
      - Energy
    - CONSTRUCTION
      - Seasonality
      - Resource
      - Budget
      - Availability of Labor
      - Availability of Materials
      - Availability of Equipment
      - Organization
      - Energy
      - Technology
        - Knowledge
        - Availability
    - OPERATION AND MAINTENANCE
      - Organization
        - Administrative Competence
        - Technical Competence
        - Lack of Government regulations
      - Hydraulic Design
      - System Control
      - Flood Protection
      - Materials, Equipment, Labor
      - Budget
      - Demand
      - Seasonality
      - Water Rights/Allocation
    - LOSSES
      - Seepage
      - Hydraulic Design
      - Evapotranspiration
      - Aquatic Growth
      - Flood Protection
    - RECOVERY SYSTEM
      - Social Structure
      - Drainage
      - Soil Characteristics
      - Water Management
  - EFFECTIVE DEMAND
    - LAND CONFIGURATION
      - Size
      - Technical Assistance
      - Land Forming
    - SOIL/WATER/PLANT RELATIONSHIP
      - Soil Characteristics
      - Climate
      - Cropping Pattern
    - AGRICULTURAL PRACTICES
      - Knowledge
        - Sowing Rate
        - Fertilizer
        - Seed Bed
        - Weed Control
        - Pest Control
      - Expected Income
      - Social Structure
        - Power Relationships
        - Income Level, Cultural Values
        - Land Tenure
    - WATER MANAGEMENT
      - Knowledge
        - State of the Art
        - Farmers
        - Application Rate
        - Timing
      - Attitudes/Values about water
      - Land Configuration
      - Organization
      - Agricultural Practices
      - System Control
      - Methods of Irrigation
      - Irrigation Practices
    - NON-FARM DEMANDS
      - Domestic
      - Trees
      - Livestock

tal requirement.

Similarly, groundwater inventory has been scanty, localized and generally inadequate for purposes of complete resource evaluation. No long-term records are available, drawdown-recovery data exist for only a few areas, and no evidence was furnished of a regular program for hydrogeological study. Exploitation of these water resources has been permitted to proceed without adequate planning, reflecting further lack of knowledge of the resource itself. No significant attempt at conservation has yet been undertaken, although an interest has been expressed in groundwater recharge. The technology to optimize the usage of surface and groundwaters exists outside Afghanistan, and is probably known to a limited extent at Ministry level or equivalent, but research and investigation leading to practical applications appear to be at a rudimentary stage, at best.

Adequate soil productivity investigations, including determinations of soil fertility, have probably never been made in Afghanistan, at least to any area-wide extent, and consequently land capability classification does not exist. A limited and very generalized soil reconnaissance survey was made by a UN group in 1963. Soils laboratories visited were deficient in experienced staff and modern equipment, and appeared to be more concerned with water analysis than soils. There was no evidence of a national soils policy or of any country-wide soils investigation programs.

Records appeared to be incomplete and unreliable, due again, perhaps, to inadequate or inexperienced staff.

2. Hydraulic Design

As related to on-farm irrigation supply systems in Afghanistan, hydraulic design suffers initially from a lack of relevant hydrologic data, of which farmers' groups have only an empirical awareness. Additionally, conveyance systems are less subject to acceptable hydraulic design than they are to land configurations and right-of-way limitations. The degree of technology resorted to is often primitive, for assistance to farmer groups in remote areas from such government agencies as have sufficient technical ability is limited and often non-existent.

Additional constraints on the design of the supply system are presented by limited energy and budgetary resources: a small pumping station that would obviate an overly-long conveyance system could well be precluded because of lack of power and fuel, as well as by the meager funds available for the purchase of the equipment itself.

3. Construction

Particularly where the building of a sizable river diversion structure, dam, or weir is concerned, construction operations of supply systems are subject to the magnitude of streamflow that must be diverted during such

construction. Such flow patterns are season in nature. The normally small budget at the disposition of the average farm group, and the limited availability of skilled labor (such as carpenters and masons), construction materials (often under the control of the Government), and needed equipment, provide further constraints to construction work. Generally the organization at the community level in Afghanistan is limited insofar as construction experience and the requisite technological knowledge is concerned. Such expertise may well be available at provincial or state capital headquarters, but it is frequently difficult to have this knowledge disseminated to remote areas. Energy limitations, if not their outright lack, are additional constraints because they limit the use of power equipment that might facilitate and improve construction.

4. Operation and Maintenance

At present there is no DRA organization for the operation and maintenance of the small-scale irrigation systems. The Ministry of Water and Power has indicated that it plans to have a section in their new organization for this purpose. However, it expects that a country-wide operation and maintenance program for the private, small irrigation systems lies ten years in the future. RDD does have a maintenance section but it is greatly understaffed and there is no budget for implementation operations.

Local organizations for system operation and maintenance exist at

the community level. The structure of such organizations depends mainly on the size of the individual system. Organizational operations are hampered by lack of administrative competence and technical shortcomings.

With proper hydraulic design, small-scale irrigation systems would be much easier to operate and maintain. There is virtually no control of the amount of water entering these systems (except for a few systems that have benefited from RDD-assisted hydraulic design). Protection from flood damage is minimal. The amount of water bears little relationship to crop requirements. The comments made under "Construction" concerning materials, equipment, labor, and budget are equally applicable to the operation and maintenance of small-scale irrigation systems. The lack of government regulations is conducive to permitting inequities in the use of water.

5. Losses

An on-farm irrigation supply system is subject to many losses which can materially reduce the flow originally diverted from the river. These losses, which have been estimated for Afghanistan to average about 65 percent of the total supply (or, indeed, all of the supply in the case of a major structure destroyed through uncontrolled flood flows) are caused by the following:

- Seepage through pervious soils through which the conveyance

system is excavated.

. Inadequate hydraulic design. In this instance it could contribute, through oversized conveyance channels, to increased seepage and excessive canal excavation.

. Evapotranspiration from large plants, shrubs and bushes contiguous to the conveyance system.

. Aquatic growth within the conveyance system impeding normal irrigation flows, and also contributing to evapotranspiration losses.

. Inadequate flood protection of principal structures which could expose such structures to damage during floods, with a consequent loss of irrigation flow as has been noted above.

6. Recovery Systems

Recovery (drainage) systems are usually needed to prevent waterlogging, or to improve waterlogged soils with attendant high salinity. In Afghanistan there is a tendency for water users at the head of a supply system to appropriate more than their fair share of irrigation water, a practice which if unchecked and uncorrected usually eventually leads to water logging. This state of affairs is a reflection of the established social structure which unintentionally encourages lax and inefficient water management, and in so doing certain water users, because of their social position, to exceed their water allotments.

Unfavorable land configurations which have not been ameliorated through levelling or terracing can also lead to waterlogging problems, as can the prevalence of high water tables and unfavorable (i.e. low-permeability) soils. This last is not too widespread a constraint, as many of the soils in Afghanistan are more pervious than otherwise. Water recovered through the operation of drainage systems may be returned to the river, or used to replenish groundwater aquifers; in some cases, water recovered from a drainage system can be further utilized for augmenting an irrigation supply.

C. EFFECTIVE DEMAND PROBLEMS

1. Land Configuration

The natural terrain features generally found in indigenous community irrigation systems (which, in Afghanistan, deliver water to approximately three-fourths of all irrigated land) require substantial modification before efficient surface irrigation methods can be applied. Farmers have managed to effect a measure of land levelling by their own devices over the years, but mostly on a field-by-field basis. This has resulted in odd-shaped and uneven-sized fields with no precision grading, which has complicated the internal farm distribution system and obviated uniformity of water application to the fields. To compound the farmer's problem further, there is virtually no source of technical expertise available to

survey and design an efficient on-farm irrigation system, nor are land improvement contractors and appropriate equipment available.

2. Soil, Water, and Plant Relationships

Knowledge in Afghanistan concerning the interaction of soil, water, plants, and fertilizer is mostly concentrated at centrally-located research and educational institutions. Disseminating this information to rural sub-centers, and through them to farmers or farmer groups, has not been adequately implemented. Extension work is carried out by the Ministry of Agriculture, but its responsibility in this area does not include the education of the farmers on soil and water matters relevant to irrigation practice. This is administratively the responsibility of the Ministry of Water and Power, but circulation of such information to rural areas has not yet been implemented.

3. Agricultural Practices

Farming procedures for crop production in Afghanistan appear to be fundamentally tradition-bound. Modernization of these antiquated practices is hampered: first by an inadequate information system to educate the farmer, and then by a failure to provide sufficient encouragement, incentives, or means for the farmer to effect many such improvements.

Existing practices where improvements could be made are included

in, but not necessarily limited to, the following listing:

Land preparation	Methods of irrigation
High yielding varieties of seeds	Control of weeds, insects, and disease
Desirable dates for seeding	Fertilizer usage
Sowing rates	Use of proper tools and equipment

Additional constraints originate in the existing social structure. Local power relationships impose conditions that are beyond the farmer's means to overcome. Such a relationship is apparent within the community irrigation systems, where mirabs are selected by the jirga, or council of elders, and where consequent favoritism appears to be the norm rather than the exception.

The lack of a crop-reporting service and a minimum-price-support program, announced in advance, affects the farmer's planning. In practice, it confirms his preference for adhering to traditional cropping patterns.

4. Water Management

The first phase of water management in irrigated agriculture is concerned with the delivery of water from the conveyance system to the farm. The second phase is concerned with water management on the farm itself.

Water should be distributed among the canals and laterals in proportion to the area of land to be irrigated on a rotation period basis.

However, in most of the supply systems in Afghanistan there are no gated intake or turnout structures, and as a consequence water deliveries cannot be fixed in terms of predetermined quantity per unit of irrigated area.

Water management on the farmer's land is essentially the control of the amount of water needed by crops at a particular growth stage, and the time and frequency of application as dictated by climate and soil characteristics. These concepts are neither understood nor practiced by farmers in Afghanistan except in a rudimentary, empirical way, strongly influenced by tradition. The problem in disseminating modern water management principles is similar to that previously described for soil, water, and plant relationships.

A further aggravation concerning current water mismanagement is the fairly common practice of farmers at the head of a distribution system acquiring, through traditional use patterns, an almost incontestable right to the use of a greater volume of water than those located lower down in the system.

5. Non-Farm Demands

In many of the community irrigation systems in Afghanistan, particularly those in more remote locations, requirements for domestic use of

water, viz., potable water, laundering, food cleaning, and livestock watering, are met from irrigation water supplies in the irrigation canals (juis) which are made to pass through or near to the village. With respect to farm irrigation, the problem may not be significant considering only withdrawals for consumptive use. However, the pollution factor arising from the introduction of deleterious substances such as household sewage wastes including night soil, detergents, soaps, or other chemically non-biodegradable substances into the irrigation stream could affect water quality. The highest non-farm consumptive use comes from growing trees planted along the jui.

D. IDENTIFICATION OF PRINCIPAL PROBLEM AREAS AND CONSTRAINTS

Further intensive studies and discussions of causal effects, interrelated impacts, and the relative importance of the key variables just described were made. As a consequence, problem areas began to emerge, areas that embraced many of those elements which influenced the variables themselves. The final analysis in this Section of the Study concluded with an identification of what appeared to be principal problem areas and the most important constraints affecting those areas.

These main problem areas were found to be:

- Resources

- Conveyance systems
- Utilization

The following paragraphs describe the major constraints that were considered to influence these problem areas.

1. Resources: The analysis of this problem area led to the conclusion that a failure to optimize constituted the major constraint hampering the development of Afghanistan's soil and water resources for irrigated agricultural applications.

Insofar as water resources with irrigation potential are concerned, there is a lack of knowledge concerning locations of sources, water quality, and water quantities available, including a categorized evaluation of prior claims on surface and groundwater supplies, as well as seasonal variations over a substantial number of years.

2. Conveyance Systems: Five key constraints were apparent during the course of the analysis of this subject:

   a. Diversion structures are inadequate and in some cases may not be the most suitable means of diverting water for irrigation use;

   b. Seepage from the system impairs efficiency and is the chief cause of water loss;

   c. Inadequate flood protection is responsible for substantial

water losses until repairs can be effected;

d. Conveyance control structures are lacking or inadequate;

e. The social organization affecting water control and distribution is not fully responsive to farmers' needs.

3. Utilization: Three key constraints were found to be hampering efficient utilization of irrigation water on the farmer's land:

a. A lack of knowledge by both technician and farmer of efficient water-use practices;

b. On-farm infrastructure related to efficient water use is either lacking or inadequate;

c. Current farming practices and the lack of a soil improvement program are hindering the efficient use of on-farm irrigation water.

V. POSSIBLE ALTERNATIVE SOLUTIONS

Introduction

This Section describes possible solutions which have been considered as being responsive to the three major problem areas as defined in Section I, C.

A. PROBLEM AREA; RESOURCES

Basic constraints: Lack of knowledge of quantity and quality of resources; measures required for effective utilization; need for exploitation and conservation regulations.

Possible Solutions:

1. Establishment of a National Water Resources Commission. A National Water Resources Commission would be an autonomous coordinating and policy-making group for the purpose of reviewing and approving all major water resources projects before operating funds were made available. The organization character, staffing and responsibilities of such a Commission are given in Appendix 3. Its authority, however, would enable it to implement the following actions; these activities themselves constitute possible solutions within the Resources problem area.

a. Inventory of all significant surface waters and groundwaters;

b. Upgrading of the hydrometeorological network to improve the caliber of the data obtained and required for water resource project planning;

c. Investigation of principal groundwater sources through drilling and pumping (drawdown and recovery) test exploration programs;

d. Investigation of more effective and efficient means and measures of water resource utilization such as, but not limited to, the artificial recharge (see definition below) of developed groundwater sources; consideration of runoff irrigation (from a water availability standpoint only).

2. Implementation of an immediate groundwater development program for selected areas.

(The implementation of such a program would not be dependent upon the establishment of the aforementioned Commission, but would require a prior groundwater inventory to be made of any designated areas for such development.)

This program would comprise the following elements which would be implemented in selected areas of Afghanistan to improve and increase existing and new sources of irrigation water:

a. A well-drilling program limited to relatively shallow wells (not exceeding 25 m. in depth where small-bore rigs are

available);

b. The enhancement of developed groundwater resources by artificial recharge. (Artificial recharge is the term used for introducing water, either through percolation through the soil using any of various arrangements of surface application, or by injection into a water-bearing soil stratum, known as an aquifer.)

3. A comprehensive soil inventory and description.

A soil inventory would describe the soils of different areas and the description would be coded and incorporated on soil maps. Soil maps are a basic tool for selecting a system of soil management. The maps show the kinds of soil in a field and farm — essential knowledge for selecting from the various available soil-management practices the combination of practices that is best suited to the soil and to the resources, skills, and desires of the farmer and rancher.

Interpretations of soil maps are physical and economic analyses of the alternative opportunities available to the users of the land. They indicate capabilities of the soils for agricultural use, adapted crops, estimated yields of crops under defined systems of management, presence of specific soil-management problems, opportunities and limitations for various management practices, and problems in nonagricultural use.

4. A soil and water conservation program for irrigated catchment areas.

Soil and water conservation within an irrigation basin concerns the protection of soil resources against erosion and the improvement of the water control system. Conservation measures to effect this would include:

a. The imposition of controls affecting grazing, the felling of trees and the harvesting of other plant life, and burning;

b. Vegetative activities such as afforestation, and the seeding of selected grasses, forbs, herbs and shrubs; and

c. Construction operations such as terracing, and the installation of dikes, levees, diversion and contour ditches, and other water-detention facilities.

5. Construction of surface water storage reservoirs.

These storage reservoirs would store water for future irrigation use. They could be formed by sizable structures across rivers; the resulting reservoir could have considerable capacity, with carry-over storage from one season to the next. Smaller reservoirs, or ponds, could be formed from embankments or dikes, and could store water temporarily from various sources, such as irrigation flows on certain farm areas, overland runoff during high-intensity rainfall, or flow received from subsurface sources.

B. PROBLEM AREA: CONVEYANCE SYSTEMS

Basic constraint (B-1) Current diversion structures need to be improved and other means of capturing water need to be investigated.

Possible Solutions:

1. River Diversion structures.

Permanent structures. Where rivers can be spanned economically by a weir, a permanent structure diverting the river flow to the conveyance system could be considered; this would either upgrade or replace an existing installation. The structure should be designed to withstand a flood having an estimated peak frequency of one in 50 years. The elements of the structure should include sluiceways for silt control, control gates at the canal intakes, and an overflow weir to function as a spillway.

Semi-permanent structures. For other wider river locations where the above-described would be obviously uneconomical, a semi-permanent structure employing gabions (wire mesh prisms filled with rocks and laid in place like riprap) could be considered. Such a structure should be designed to withstand a flood having an estimated flood frequency of once in 10 years. The structure should, however, include a permanent headgate and sluiceway, notwithstanding the knowledge that because of river aggradation, or degradation, or course change, modification to or even

relocation of the intake might be required in the future.

Relocation of existing diversion structures. Where additional benefits would be possible such as:

a. Improved canal characteristics (non-silting or non-scouring velocities);

b. Ability to irrigate more or better lands; and

c. Greater protection from river action afforded to the structure;

then relocation of the diversion structure could be considered.

Consolidation of existing diversion structures. Where separate irrigation systems are contiguous or in close proximity, and where the topography is conducive, economies in maintenance and operation may often be realized by consolidating the separate diversion structures into one. A few connecting canals would be required to interconnect the existing systems, and adjustments would also have to be made in the carrying capacity of certain main canals. Reductions should thereupon be realized in overall canal maintenance needs, seepage losses, and other losses that might be attributable to the poor hydraulic design of the original systems before consolidation.

2. Other Irrigation Supply Schemes.

Pumped water from surface runoff sources. Pumps could be utilized to provide irrigation water from rivers. Unnecessarily long canals could

thus be eliminated, and with them attendant losses. Pump diversion would also obviate the need for run-of-river diversion structures, but would require skilled operators with a knowledge of maintenance procedures as well as an energy source. Alternative energy sources to fuel and electricity (in long-term considerations) could include wind and solar power.

Pumped water from karezes. Dependent upon the capacity of the aquifer tapped at the uppermost karez well, the suitability of arable land in its vicinity, and the assurance of a favorable B/C analysis, consideration could be given to replacing the karez system with pumps at the uppermost well and at the outlet of the system (tapping the aquifer itself at that point). If feasible, this would enable more land to be irrigated and would obviate the periodic and hazardous maintenance of the karez now required.

Controlled flow from karezes. Instead of permitting the karez to flow continuously, the karez flow could be collected in a pipe, thus providing a means of transmission paralleling the karez tunnel. If equipped with a valve, the pipe system could be closed when irrigation flows are not required, thus allowing unneeded flows to be stored in the main supply aquifer. Alternatively, karez flow could be stored in a small reservoir, to be used when needed.

Basic constraints (B-2) Seepage within the system is the chief

cause of water loss and lowered efficiency; and poor maintenance is a further source of loss.

Possible Solutions:

1. Lining of canals.

The lining of canals on a selective basis would minimize seepage for those systems where such losses are considerable and critical. Linings are usually relatively permanent (clay linings have considerable shortcomings and for several reasons would not be recommended) and are of three distinct types:

a. Rigid - using cement or asphaltic concrete paving cast in place or formed from precast slabs;

b. Membrane - linings prefabricated from plastic, butyl rubber, or compounds of asphalt combined with jute, paper, or fiberglass. Such linings are either exposed or covered with a layer of soil and sand; and

c. Sealing compounds - liquids sprayed on ditch faces to reduce seepage either by dispersing clay materials, or by filling soil pores to form a membrane.

2. Shortening of lead canals.

This possible solution has been referred to in the previous discussion of Solution A, 1.

3. Improved Maintenance.

During flood seasons many of the primitive irrigation systems are subject to flows for which they were not designed. In addition to carrying and depositing a heavy silt load in the canal, these flows are conducive to over-topping of banks with consequent cave-ins, and the general impairment of the conveyance system.

During other periods aquatic growth and weeds have been allowed to grow in the canals.

Improved maintenance would provide for a regularly scheduled excavation of silt, the clearing of aquatic growth, the removal of obstacles, and the repair of damaged canal sections. These deficiencies impede flow and also contribute to excessive losses.

Basic constraints (B-3) Inadequate flood protection causes major water losses.

Possible Solutions:

1. Headgate control structures.

There are almost no permanent intake or headgate structures for diverting water from the rivers into the main canals of the irrigation systems. The main canal is consequently subject to damaging flows during high river stages; this causes erosion and over-topping of canal banks, inundation of croplands, and siltation of the canals.

A permanent or semi-permanent diversion structure with headgate controls to canal and sluiceway would prevent this recurring damage. The permanent weir section could be masonry or concrete, with gabion construction for the semi-permanent diversion structure. The headgate or regulating structure could be masonry.

2. Siphons

Inverted siphons could be used where irrigation ditches cross roads, canals or stream channels. The conveyance system is thus protected against damage from uncontrolled flows in the channels and impedance of flow from other sources is obviated. Siphons may consist of a concrete box structure or a pipe (either concrete or steel). Their design must be based on adequate hydraulic analysis.

3. Flumes

Flumes could also be used to carry irrigation water across small waterways. Their cost is usually less than an inverted siphon, but they may require more maintenance or earlier replacement, and the necessary supporting sub-structure might not be practical in some locations. Flumes could be made of pre-cast concrete, sheet metal or wood.

4. "Cut-and-cover" canal sections

These sections could be used to convey water where canals cross waterways, or traverse steep slopes where debris deposition or slides are a

problem from the slope above the canals. Such a conveyance has a rectangular cross-section, and is so excavated that the structure will be below ground surface. The sides and bottom are usually rubble masonry with a pre-fabricated concrete slab placed on top of the masonry walls. The structure is then covered over with fill material as necessary.

4. Diversion Dikes

Diversion dikes, or guide levees, could be constructed for channeling rainfall runoff which collects in waterways above fills and canal banks. These usually originate above the canals and continue for short distances below, thus confining such runoff and preventing it from destroying long sections of canals. Such diversions or dikes could also keep runoff from inundating irrigated land. Construction could be effected with earth fill materials, loose rock, concrete, or masonry walls.

6. Sluiceways

Sluiceways could help prevent canal siltation by removing silt or other matter from the bottom of the intake channel before it has a chance to get into the canal system. Sluiceways are frequently incorporated with the headgate structure.

Basic constraints (B-4) Irrigation water control structures are lacking or in need of improvement.

Possible Solutions:

1. Division boxes.

These structures could be used to divert irrigation water from laterals to secondary canals, from one field ditch to another, or divide a stream between two or more laterals or ditches. The division boxes are generally box-like structures, built of rubble masonry or concrete with two or more outlets (commonly called turnouts) used for the delivery of water. The size of each outlet would be proportional to the amount of water delivered. Gates would be required for closing or regulating the flow into each separate outlet. The outlets of many division boxes are metered so that measurements can be made of the quantity of water.

2. Checks.

Checks could be placed across canals, laterals, and field ditches to raise the water level to the elevation that would enable the required amount of water to be released to a field. The water level should be kept at nearly the same height above the ground surface for the width of the field being irrigated, so that flow into each of the basins, contour borders, or furrows will be equal. Permanent gates could be used in checks, or they could be equipped with flash boards or undershot sliding gates to control the water level.

3. Outlets or turnouts.

These devices could be used for releasing the irrigation water from a canal or ditch to a field. They would control the amount of water being diverted into each basin, contour border, or furrow. The choice of outlet would depend on method of irrigation being used.

4. Drops

Drop structures could be installed in ditches on land with considerable slope. These would permit the ditch to be constructed as a series of relatively flat channels, each at different elevation, at non-erosive grades. They should be generally spaced so that the difference in elevation at each drop does not exceed 50 cm. Drops dissipate the energy of the falling water using a stilling basin with a concrete or rock apron, so that it does not erode the ditch.

5. Metered gate structures

An accurate determination of how efficiently irrigation water is being used is dependent upon the measurement of that water. Sufficient metered gates for this purpose could be installed in drops, checks, or turnouts. A metered gate is a fixed dimension opening calibrated for measuring the streamflow over or through which irrigation flows pass. Such measuring devices measure the rate at which water is being delivered. They may consist of weirs, orifices, Parshall flumes (generally employed by technicians making water-use studies), and commercial gates calibrated by the manufacturer.

6. Closed Pipe Distribution System

Pipelines could provide a number of advantages over open ditches for the distribution of irrigation water. In reducing seepage losses, they would be comparable to concrete-lined ditches. Evaporation losses would be eliminated and weed control unnecessary. The area that would otherwise be occupied by open ditches could be planted to crops. Generally, maintenance costs would be less than for open ditches. (Increased use is being made of pipelines in areas where water savings, costs, or the full use of all irrigable land are important considerations.) Pre-cast, non-reinforced concrete pipe is the most widely used type for irrigation pipelines of low pressure.

Basic constraints (B-5) The social organization of water control and distribution is not fully responsive to farmers' needs.

Possible Solutions:

1. Training Program for Mirabs and Chakhbashis.

Mirabs and chakhbashi assistants are currently responsible for managing the community irrigation system. They oversee the distribution of water from the main canals to the numerous laterals along those canals: they settle disputes involving the use of water; and they organize the water users for both periodic and emergency maintenance and system repair. Despite their unfamiliarity with hydraulic concepts, mirabs and chakhbashis do a fair job of distributing water throughout the systems.

To improve overall efficiency in water use, the mirab and chakhbashi could be given some basic training in both modern agricultural practices and elementary hydraulic principles. Following these instructions in the proper distribution of water within their systems, monitoring of the degree of assimilation and the effectiveness of this training could be administered by the same agency responsible for the initial teaching program.

2. Operation and Maintenance Standards.

There is at present no governmental agency that is effectively concerned with the operation and maintenance of small-scale irrigation systems in Afghanistan. Such work is currently implemented through communal actions headed by the mirab, using simple tools and primitive techniques practiced over many years.

The establishment of standards for the operation and maintenance of small-scale conveyance systems would increase the efficiency of these systems, assuming that the agency responsible would assist in providing material, equipment, and a source of financial assistance for this work, as well as concomitant training and supervision.

3. Water Rights

Water rights in Afghanistan are based upon Islamic Law, which in effect states that water is a free, natural resource which is to be shared equally by all and not to be sold. Accordingly, land owners in each region have

devised a system whereby the irrigation water is allocated proportionately, based upon the size of land holdings. Although this system of water allocation is somewhat crude, it could theoretically work. In practice, however, traditional rights are sometimes ignored by powerful large landowners, by landowners at the heads of irrigation systems, and by other unscrupulous water users. Consequently, those at the lower end of the system often receive less water than they have a right to.

The enactment of water rights legislation could contribute to the equitable and efficient use of water in Afghanistan. Such legislation would be concerned with nation-wide standardization of water use for each region and for each crop, as well as enforcement of the newly legislated rights to irrigation water.

C. PROBLEM AREA: UTILIZATION

Basic constraints (C-1) There is a lack of knowledge by technician and farmer of efficient water-use practices.

Possible Solution:

Initiate research; develop irrigation guides; and give technician and farmer training courses.

Research could produce data on proper rates of water application based on local soil/water/plant relationships.

Irrigation guides, developed for each locality, could indicate the

proper method of irrigation for each crop, rate of application of irrigation flow, duration of time required to irrigate a given area, and the frequency of irrigation according to type of plant, soil texture, and depth.

In-service training courses could be given to technicians and subprofessionals that would teach them current developments as well as established, approved practices related to irrigation agriculture. Information learned from these courses could then be disseminated to farmers on a broad basis. Farmer training could further be carried out through field demonstrations, informal classwork exercises, and through the use of media facilities available.

Field agents could be supplemented by local village workers recruited from among the more progressive farmers. They would receive some on-the-job training, and be required to assist in promoting production campaigns within the village. They would receive a small salary, but continue with their farming operations.

Basic constraints (C-2) On-farm infrastructure related to water-use efficiency is either lacking or inadequate.

Possible Solutions:

1. Improvement of on-farm distribution system.

Many of the possible solutions for Conveyance Systems previously described

(see Section V Basic Constraints B-2 and B-4) would be applicable to on-farm distribution systems but at a much reduced scale. Additional control devices to regulate water onto farmers' fields are somewhat different, however. For this function, siphon tubes formed of plastic pipe or hose could be used; lath boxes (spiles) could be made, inserted through embankments, and plugged with sod when not being used; or tile pipe could also be considered for installation in embankments or levees that could be uncapped when water is required.

Concrete blocks, fired brick, and rubble masonry could be used for the small structures suggested; other than cement, and materials for making these structures would be available locally.

2. <u>Levelling of the land.</u>

All surface methods of irrigation require a smooth land surface for uniform distribution of water. Good land preparation to obtain this smoothness is the first step in installing any surface irrigation system. Such preparation could be conducive to more efficient control of water; improved surface drainage; reduced soil erosion and fertility loss; and possible irrigation of a larger acreage with a limited water supply due to a more efficient use of water.

Several degrees of land preparation could be considered, depending upon the nature and extent of the specific problem:

a. Land smoothing is the removal of minor irregularities of the surface without altering the general topographic pattern. The practice is applicable to nearly level land, or land with slight or irregular slopes;

b. Rough grading is the removal of knolls or ridges, and the filling of gullies and other low areas. These represent greater irregularities than those described under land smoothing. Cuts and fills are relatively heavy.

c. Land levelling is the reshaping of the land surface to a planned grade, and usually consists of levelling the surface of each field to a single plane or series of planes. These planes could slope both in the direction of irrigation and at right angles to this direction (as in furrow irrigation); or could slope in the direction of irrigation only (as in border irrigation); or could be level in both directions (as in basin irrigation).

3. Improvement of on-farm drainage.

Effective drainage, both surface and internal, is essential to successful agriculture. There is little point in irrigating a crop during the early part of its growing season only to have it damaged before reaching maturity by poor drainage.

Where land is not naturally well-drained, artificial drainage could

be provided before the irrigation system is installed. Natural watercourses could be used to carry away flood runoff, thus preventing inundation and erosion. Artificial drainage works could eliminate wet spots occuring in fields because of seepage from hillsides or from irrigation canals or laterals, and could be used to remove standing water from depressions where an accumulation of white salts on the surface of the soil is sometimes noticed.

4. Augmented water supply during droughts.

Where an adequate and conveniently-located aquifer has been identified, consideration could be given to the construction of a shallow well which would provide an irrigation supply for one or more farmers' fields.

Basic constraints(C-3) A soil improvement program related to water use is urgently needed.

Possible Solutions:

1. Increasing of fertility levels.

The need for expanding the productivity of Afghanistan soils is apparent. Fertility levels could be raised through fertilization and soil amendments, which would provide a replenishment and enrichment of major nutrient elements in the soil for optimum plant growth. The extent of such replenishment could be determined from a soil fertility analysis which would indicate inherent fertility levels.

2. Reclamation of the soil

Reclamation is needed in many areas of Afghanistan to remove deleterious or excessive salts from the plant root zone of the soil profile. Chemical treatment of the salts (where indicated by soil tests) together with drainage and leaching could provide the basis for the development of a more favorable environment for soil/water/nutrient interaction and consequent plant growth.

3. Subsoiling

Some areas of Afghanistan have soils with limiting or barrier layers; these comprize zones of more compacted soil materials, or concretion layers within the soil profile. These conditions limit plant root development and restrict internal soil drainage.

This problem could be corrected by subsoiling to break up or shatter the impervious or semi-impervious layer in the subsoil. This would enhance water infiltration rates; would afford the plant root more of the soil profile zone for its development, and respiration; and would improve internal drainage.

Basic constraints (C-4) Current farming practices are not conducive to efficient water use.

Possible Solutions:

1. Land preparation, proper seeding, fertilizer application, and weeding.

Land preparation includes plowing; harrowing; smoothing the soil;

the forming of ridges to separate border strips or basins for closegrowing crops; and the forming of furrows for other crops, particularly root crops.

Proper seeding using quality seeds in a more organized fashion would contribute to better plant distribution, whereby plants in a row are systematically spaced to encourage equal soil moisture zones from which moisture and nutrients can be withdrawn.

Fertilizer application at the recommended times and rates would facilitate the growth of more vigorous plants with well-developed root systems; these would penetrate further into the soil, tapping moisture from a larger soil-moisture zone.

Control of weeds would eliminate competition for available soil moisture and plant nutrients and would accordingly encourage plant growth and development.

2. <u>Cropping systems, including rotation and intercropping.</u>
Rotation means growing a warm and a cool-season crop, leaving the land fallow; or growing a perennial crop in systemized sequence to maximize land use. Either procedure would stimulate increased production. Many rotations could be developed.

Intercropping refers to the growing of two or more crops simultaneously on the same plot which do not interfere with each other at harvest. Possible examples would be the over-seeding of wheat with clover; a

mixture of clover and wheat in an orchard; climbing beans in maize (corn); or the intermixing of two vegetables.

Basic constraint (C-5) Runoff irrigation is not being considered in many areas of Afghanistan.

1. Possible Solution:

The basic objective of runoff irrigation is the interception of the maximum amount of rainfall runoff through impoundment and subsequent percolation to and retention within the plant root zone. Its practice is applicable to semi-arid areas with an annual rainfall of at least 100 mm.

Natural runoff from rainfall is intercepted and diverted to either microcatchment areas or to terraces; the areas are bounded by low earthen or rock-filled walls. Openings in the walls function as spillways, allowing excess water to be released.

The practice is simple in concept but somewhat sophisticated in implementation. It could be considered for some extensive areas of arable lands in the country now uncultivated, and it has a potential for materially increasing agricultural production. However, climatic and soil conditions must be well known and conducive to the practice. Moreover, considerable technician and farmer training, as well as continuous supervision during the initial years of implementation, should be provided to ensure success.

VI. POTENTIAL IMPACT OF TECHNICAL PACKAGES

A. Introduction

Following extensive study and discussion of the possible solutions, it was concluded that no single solution could be assigned to any specific subsector problem. Accordingly, technical package solutions were developed.

This Section describes these technical packages, identifies the inputs (technical assistance, commodities, equipment, training, and type of financing) that would be required for their implementation, and discusses their potential impact on irrigated agriculture in Afghanistan in general, and upon the individual Afghan farmer in particular.

B. Technical Packages

1. Inventory. This package represents a long-term program involving the Ministries of Water and Power, and of Agriculture, plus the Rural Development Department. As the Air Authority has the responsibility for operation and maintenance of meteorological stations and the dissemination of data therefrom, it would also participate in the program.

The inventory package is concerned with the inventory of the natural resources of soils, surface water, and groundwater. It would include the upgrading of soils laboratories; the expansion to first-class standards of

the hydrometeorological network and ancillary support services; and improving the capability for groundwater explorations to be made.

This effort would require some inputs of commodities and equipment. Technical assistance has been provided in the past, and a judgment assessment is that more should not be required for initial package implementation. Similarly, foreign training should not be considered until the project were well underway and specific training needs could be more precisely delineated.

Such an inventory would ultimately enable the na ion to know the extent of these resources so essential to irrigated agriculture, as well as providing the means for obtaining basic soils and hydrologic data; these data are needed for improving planning and design operations, and could also be useful in determining the actual value of irrigation water.

The individual farmer would eventually benefit as the value of these resources was finally understood and appreciated, as a more efficient use of soils and water would lead to increased production and, ultimately, as his income would consequently increase.

2. System Infrastructure. This package is concerned with the application of technology to improve and upgrade the irrigation system: diverting water from its source and conveying it to the farms within the service area being irrigated. It covers the utilization of techniques affecting diversion and water control for open ditch distribution systems.

It assumes an adequate supply of water is available, and in this respect is relevant to Package I, Inventory.

Diversion structures could be permanent or semi-permanent. Sound hydraulic principles should govern the design of distribution systems, including terminal facilities, with special emphasis on: (1) upgrading of diversion structures; (2) flood protection; (3) water control structures; and (4) seepage losses (canal lining).

Equipment and commodities would be needed as well as in-service training programs for professional, sub-professional, and technical staff. On-the-job training could be provided by consultants and expatriates. Grant and credit funding would be needed for the implementation of the technical package.

In addition to the rehabilitation of irrigation systems and a consequent augmentation of the irrigation water supply, the package would provide an additional factor favorably affecting increased yields and improved quality of crops grown, with the ultimate end of increasing and stabilizing the farmers' economy.

3. On-Farm Infrastructure. On-farm infrastructure is concerned with the physical characteristics of an individual farmer's land holding or farm. The elements of on-farm infrastructure included for improvement in this package are land levelling, field drainage, on-farm distribution systems, and on-farm wells. The improvement of these elements would

permit the farmer to apply water and other inputs with greater efficiency. The maximization of these inputs could result in greatly increased yields with considerably less labor requirement.

The implementation of a farm infrastructure improvement program would require technical assistance, training, commodities, equipment, funding for demonstrations and for intermediate-term credit. The Agricultural Bank would be the agency responsible for providing assistance as well as for implementing this program.

In addition to the rehabilitation of irrigation systems and a consequent augmentation of the irrigation water supply, the package would provide an additional factor favorably affecting increased yields and improved quality of crops grown, with the ultimate end of increasing and stabilizing the farmers' economy.

4. Soil Improvement Program. A soil improvement program would be based on soil management principles, and would promote the reclamation of saline or alkaline soils, and the improvement of soil fertility. Such a program could benefit farmers by increasing crop yields and by improving soil tilth; the latter would enhance water-use efficiency on the farm.

This program would be closely allied to programs for System and On-farm Infrastructures. It would also be related to both Research and

Extension and Training Programs.

Inputs for program implementation would include technical assistance; training; commodities; equipment; and funding for demonstration plots and for credit resources.

DRA Ministries and agencies which would be involved in the implementation of the program would be the Ministries of Water and Power, Agriculture; and the Agricultural Bank.

5. Research. A strong research program for developing and testing varietal response to soil/water/plant and nutrient interactions as well as cultural practices would significantly benefit Afghanistan's agricultural programs. All farmers could potentially benefit by adopting more modern farming practices as developed and released by the nine research institutes in the country.

This program is a vital necessity for upgrading the quality of extension information to be disseminated to farmers, for developing irrigation and drainage guides, and for testing new technology such as run-off irrigation. The program would serve as the font of information used in the Extension and Training Program.

Financial implications are indicated for technical assistance, foreign training, commodities, equipment, and some funding for demonstrations. The Ministry of Agriculture is the DRA agency responsible for

research.

6. Extension and Training. The Extension and Training Program is structured to upgrade the quality of technical advice being given to farmers on farming practices in Afghanistan.

Both the individual Afghan farmer and the country's farming community as a whole could benefit from the introduction and adaptation of more modern farming practices that would have as their objective increased yields and production levels.

This package should begin with a progressive schedule of upgrading the skills and knowledge of present cadre and staff through in-service training. Further sophistication could be achieved through technical assistance and foreign training. The program would need support for acquiring commodities, equipment, and some funding for sponsoring demonstrations.

Implementation would be effected through the Ministry of Agriculture.

7. Groundwater Development. This package is concerned with the necessary exploration and development of wells, springs, karezes and galleries; a program for the introduction of artificial recharge; and an extensive groundwater testing program.

The impact of such a program that would accrue to the nation

would be the increased knowledge of the groundwater resource potential throughout Afghanistan, knowledge that would be of considerable value in the more efficient utilization of present groundwater systems; the control of pumping and drawdown; and the planning of future irrigated agricultural developments that would be dependent upon groundwater resources either as a prime or supplementary source of irrigation water.

The farmer would benefit from a groundwater program where adequate supplies of groundwater were discovered through investigation, or where present inadequate supplies could be increased through artificial recharge. The increased water supplies could improve crop yields and hence farmers' incomes.

Inputs required would be small amounts of technical assistance; training; and laboratory and testing equipment. Some additional drill rigs would be needed to augment present inventories.

The Ministry of Water and Power would be involved in the program's implementation, as well as the Rural Development Department and the Agricultural Bank.

VIII. ADDITIONAL UNEVALUATED CONSTRAINTS

Although the Team's development of the technical and policy packages was influenced by the constraints that have been described in detail in Section IV of this Report, there are other possible constraints or limitations, some of a socio, cultural nature, which although beyond the purview of this Study, should be borne in mind for future reference. These unevaluated constraints (insofar as their impact upon the designated respective packages is concerned) are outlined below. Some of them could significantly influence any decision concerning the future implementation of the packages.

- Traditional agricultural production methods: The insistence of farmers in adhering to traditional but outmoded methods of agricultural production limits and frequently negates many recommended inputs. This has been one of the root causes of disappointing returns on some major irrigation projects. Irrigation water is simply one input affecting production: fertilizer, quality seed, and good cultural practices are equally necessary, for regardless of its application, irrigation water applied to sterile sand will not produce a grain of wheat, a boll of cotton, or an ear of maize.

Afghanistan desperately needs a program acceptable to its farmers that will induce them to accept progressive agricultural practices.

- Water law/water rights/water charges: The Team has been shown a translation of a decree setting forth water rights. Field trips to several projects, and the reading of reports touching on the subject, have been unconvincing that a national water law exists, or that water rights are being equitably administered or enforced. There was no indication throughout Afghanistan that water charges are either being made or are contemplated. The absence of these elements, so essential to the success of many of the solutions contemplated, constitutes a serious limitation to future irrigated agricultural development.
- Soil conservation: The effectiveness of vegetative and mechanical measures for protecting water catchment areas against further erosion and other deleterious effects of surface runoff would be dependent upon concomitant regulatory controls such as restrictions limiting grazing, wood harvesting, or burning. Such restrictions could engender adverse impacts where the controls conflicted with traditional practices. Because the program was not considered as significant as other possible solutions studied,

further investigation of a soil conservation program was abandoned.

- Land Tenure: Land reform legislation was passed during the drafting of this Report. Its full import, and the extent and timing of its implementation, were not available to the Team.
- National energy and material resources: The relaxation of present restrictions on energy and material resources, eventually permitting the farmer access to these elements, could significantly contribute to his increased production, and consequently could influence the possible impact of the packages.

The technical and policy packages have also not been subjected to possible limitations that could be imposed by their relevance to the USAID Country Plan for Program Development, its priority committments, and its timing.

AFGHANISTAN

Annex 1

IRRIGATED SUB-SECTOR ASSESSMENT

Use of Ground Water and Recharge to Increase Agricultural Production

by

Leonard Schiff, P. E.

Consulting Hydrologist and Agric. Engr.

Kabul, Afghanistan
December, 1978

AFGHANISTAN

IRRIGATED SUB-SECTOR ASSESSMENT

Use of Ground Water and Recharge to Increase Agricultural Production

TABLE OF CONTENTS

Table of Contents (cont'd)

FIGURES

IRRIGATED SUB-SECTOR ASSESSMENT

Use of Ground Water and Recharge to Increase Agricultural Production

SUMMARY AND CONCLUSIONS

There are a large number of wells, both shallow and deep, in Afghanistan to augment surface runoff supplies of water for irrigation. In times of low runoff wells become an even more important water resource for agricultural production. In some areas ground water is the only source of water (such as the use of karezes). More wells are going in, the tendency is to place emphasis on the shallow hand-dug well to help the rural poor. Generally the rural poor are not on the upper end of distribution systems and thus suffer from insufficient water.

Ground water levels are declining in a number of areas and there is fear, particularly as more wells go in, that declines will continue. Declines are expected in a number of areas that are being planned for development.

Mr. Asimi, President of Planning, Water and Power, in programs involving wells, suggests consideration of artificial recharge (not practiced in Afghanistan as yet). Mr. Asifi, President of the AgBank stresses the use of wells and is concerned about the lack of knowledge to select appropriate locations, type and optimum depth of wells, and to predict approximate yields. Dr. Raouf, President, Water and Power Engineering Company, has also expressed concern over the possibility of declining water tables in three areas for which plans are being developed. Mr. Said of the AgBank stated "that a number of farmers want to return their pumps to the Bank because their wells have gone dry".

Consequently, it appears that there is an immediate need to arrest the decline and raise ground water levels, starting in areas where there are a relatively large number of farmers, particularly rural poor. To do this an exploratory program is needed, using portable small-bore drill rigs, to obtain the following inventory to provide information enabling: (1) Determination of depth, extent and characteristics of sub-strata; (2) Delineation of the depth and extent of aquifers (water-bearing formations); (3) Determination of depths to water, available supplies, and quality; and (4) Estimation of the capacity of ground-water basins and safe yields.

Such investigations enable selection of the best sites, types and optimum

depth of wells, yields anticipated, and safe yields (to insure some water supply during periods of low runoff and droughts). Additional equipment needed is a test kit to determine water quality (as salinity and alkalinity). Sites and depth of test drilling are based on existing data available, or from the exploratory program.

Sources of ground water in a ground water development program include wells, springs, karezes, infiltration galleries or intercepting ditches. Each is discussed herein including methods to increase water yields and/or conserve water, looking toward increasing agricultural production. Ground water is used basically to augment surface supplies of runoff water, however during years of low surface supplies, ground water can become the major supply and minimize the effect of droughts.

To date ground water has been augmented by seepage from rivers and their sub-systems, diversions and conveyance systems, and over-irrigation. However, seepage is falling short of maintaining ground water levels. Consequently artificial recharge (not practiced as yet in Afghanistan) is necessary now, not only to maintain appropriate levels but increase them where necessary. The water supply for artificial recharge becomes available during years of excess runoff. Such water now wastes to deserts or swamps.

Recharge includes surface methods as grassed basins and injection methods as pits, shafts, trenches, ditches, meandering canals or combinations of these. Over-irrigation, for example, of alfalfa-cropped basins, each basin with a pit (exposing aquifer material) can fulfill a two-fold purpose, recharge and a cash return (as food for livestock). In addition to the information gathered under the inventory, it is necessary to obtain information on water movements in the surface soil of potential recharge sites. Such information is obtained with manometer-equipped infiltrometers and a soil moisture device, all described herein and references to publications noted (copes left with AID/A). Recharge with good quality surface runoff also dilutes salinity of the ground water, an additional benefit.

The programs summarized above are needed now to increase agricultural production in Afghanistan and to help all farmers, particularly the rural poor.

AFGHANISTAN

IRRIGATED SUB-SECTOR ASSESSMENT

Annex 1

Use of Ground Water and Recharge to Increase Agricultural Production

by

Leonard Schiff, P. E.

INTRODUCTION

The team leader of consultants from Experience, Inc. suggested that the section on ground water, because of its somewhat distinct nature, be attached as Annex 1 to the "Irrigated Sub-Sector Assessment". The writer was in Afghanistan from 10/16 - 12/7/78. This section follows portions of the "Key Variables" pertaining to ground water as developed by USAID/Afghanistan, Afghan representatives, and the consultants. Recommendations are considered under "Evaluation of Alternative Technical Interventions" as developed by AID/A. This approach developed a closer working and personal relationship with the Afghans that enhanced the work to increase, among other things, the water supplies for agricultural production, especially for the rural poor.

Precipitation varies from about 1000 mm. in the higher altitudes to as little as 20 mm. annually in deserts of the southwest. Most precipitation in the form of snow in the mountains is released through the summer and is the primary source of the nation's rivers and augments ground water supplies largely by seepage.

The hydrologic system is composed of ten river systems or major subsystems flowing into four basins (Oxus, Helmand, Kabul and Hari Rud). Only the Kabul outlets into the sea. Some outlet into desert wastes or swampy areas. (Using artificial recharge, some of the water wasted could be used to augment ground water supplies, particularly since additional wells, primarily shallow, are recommended in a number of areas by the Ministry of Water and Power and the AgBank).

About 80-85 percent of the population depends directly upon soil and water for their livelihood. The yearly increase in population is about 2.3%. It

is a country that can proudly claim its "fiercely independent", hard-working people. About 12 percent of the land (of a total of 250,000 square miles or 6,444,000 square kilometers) is cultivated at present. Increases in this percentage can be foreseen through proper management of surface and ground waters and the use of artificial recharge.

Ground water has existed historically and is augmented by seepage from rivers, subsystems, distribution systems and unintentional over-irrigation by some farmers. As the number of wells increase, the additional extraction of ground water will necessitate the use of artificial recharge methods and systems in some areas as discussed herein.

It appears that from historical times to the present, ground water varied from mostly low or mildly to highly saline (from various reports and by electrical conductivity measurements made by the writer in a field trip, pH measurements show no alkalinity problems). Unfortunately there is the likelihood that salinity of the soil may increase under present practices. Excessive irrigation on farms, particularly near upstream diversions or near the head of irrigation systems, actually leached salts from the topsoil, thus ensuring a better environment for agricultural production. Farms lower down have not been as fortunate, particularly from the standpoints of lack of sufficient water and insufficient leaching. (For the technically inclined, the leaching requirement, LR, is the electrical conductivity of the irrigation water divided by the electrical conductivity of the drainage water.)

Needs Based on Ground Water Problems

Needs related to ground water problems based on field trips, discussions with five Afghan Ministers and their staffs, and the President of the Water and Power Engineering Company and some of his staff, and a review of literature are:

1. Strategic locations and optimum depth of wells, prediction of yields (not only for best yields but assurance to farmers).
2. Increase yield of kareses and possibly springs and consider use of Infiltration Galleries to collect ground water.
3. Artificial recharge to augment ground water and thus surface supplies to maintain and probably increase agricultural production.
4. Management to maintain ground water at "safe elevations" for supply to wells and to minimize effect of low, surface-runoff periods and droughts (includes training of farmers, technicians, and extension workers).

Problems - Use of Ground Water

There is insufficient knowledge as to the quantity and quality of the ground water and how to effectively use this resource. It will be helpful to cite Ministers and members of their staffs (Department of Water and Power, and AgBank) concerned directly and financially with potentials for maintaining and/or increasing agricultural production in Afghanistan: "(1) Increase the supply of water by using more ground water (particularly shallow wells), (2) Increase yield of existing karezes (underground tunnels that tap ground water supplies), (3) Improve distribution and management of water."

Excerpts from a report by Azimi (President of Planning of the Ministry of Water and Power) and McMillan (Water Resources Engineer) 1977, follow: "(1) Agricultural production depends largely upon irrigation, (2) Karezes waste much ground water, (3) Most surface water supplies are unreliable due to recurrent droughts and insufficient storage capacity, hence the importance of timely ground water development, (4) Origins of subsurface water are mostly from rainfall and snowmelt (proportion sinking into the soil often higher in arid regions), also in arid regions ground water storage is often the most reliable source of irrigation water, (5) Where conditions are favorable, the use of one or more aquifers as reservoirs can contribute to the improvement of agricultural productivity and can eliminate evaporation losses, can provide a low-cost distribution system and result in cost savings when compared to surface reservoirs, the development of ground water supplies must not be neglected, (6) Artificial recharge is recommended (not practiced at present), and (7) The M.I.S. subsection (Minor Irrigation Section) concluded that a potential for ground water development exists and that farmers are interested in ground water development." If I recall correctly, Mr. Asefi, President of the Agricultural Bank, indicated at a meeting that additional shallow wells had important potential.

On a subsequent visit to the AgBank, Mr. Mohammed Said stated "that a number of farmers want to return their pumps because their wells have gone dry." Dr. R. Raouf, President of the Water and Power Engineering Co., discussed the ground water situation and two members of his staff stated that in the three areas for which they are developing plans, similar problems may occur, (artificial recharge should be considered as discussed later in this section).

Water movements through soil and substrata generally have not been related to the physical and chemical characteristics of the soil and substrata. Little information exists on water movements through soil and substrata and laterally from the ground-water tables. Information could be obtained enabling better selection of sites for wells, determination of the optimum depth of wells and management of the amount extracted, whether wells are shallow

hand-dug, shallow or deep bored.

The Ministry of Water and Power is well experienced in constructing hand-dug wells, relatively shallow and deep bored wells, and costs. In development of wells, pump tests, and pumpsets required, consultants have also contributed to this background. This Ministry also stated energy is not a problem.

More information is needed on the capacity of subsurface basins now used (at least that supplying existing wells or those that may be added). Such information will be vital, particularly as more wells go in and guides are needed as to the type and number of wells installed. The amount of water that can be safely extracted to increase agricultural production is not available, nor is the amount of water that should remain in storage to be used only when it is necessary to minimize the effect of droughts on agricultural production.

Recommendations — Ground Water

1. Explore, inventory, classify ground water (for use of wells).

First, it is desirable to determine the physical and chemical characteristics of existing ground water basins that are being used and may be used. If sufficient logs of existing wells are available it may be unnecessary to drill small-bore test holes to augment existing information. These made on existing wells are and will be helpful in determining important ground-water flow characteristics of a subsurface basin (areas through which water flows, slopes of water tables and ability of substrata to transmit water). Small-bore holes should be drilled to a depth based on the characteristics of the surface and sub-surface materials found (usually about 30 meters will be sufficient, as stress is placed on shallow wells, although deep wells are not ruled out). Emphasis is placed on helping the rural poor.

It is understood that relatively light, portable drill rigs that may be towed are available (about $12,000 has been cited as the cost of such equipment, however, additional rigs may be necessary). Holes are drilled usually on a grid system as far apart as possible, (based partially on existing information such as logs of wells, profiles of hand-dug wells, seepage from rivers and the hydraulic gradients or slopes of the ground water table). If there is an abrupt change between test holes, a hole(s) may be drilled between to establish continuity of the different substrata.

The ground water hydrologist need be on a site only long enough to select locations of test holes and to inspect test samples of materials collected

and to test water samples for quality. In this manner the hydrologist may cover a number of areas in a relatively short time.

Figure 1, next page, shows a helpful method of plotting stratigraphic characteristics or the texture of soil and substrata found (isometric projection). Also water levels and permeability designations are noted on the figure. Such information is necessary to determine the capacity of the basin, at least in the area tested, and substrata that may perch water. Data on such a figure permit determination of the hydraulic gradients or slope of the groundwater table, (hydraulic gradients along with the hydraulic conductivity or permeability of the substrata and the area through which water flows are key factors in the determination of: amounts of flowing ground water, use of ground water, rise and fall of the ground-water table, recharge, "safe" yield, and management).

Nothing as elaborate as Figure 1 need be drawn. This figure is a copy of a detailed study made by the writer in one area in South America. (Such information is also needed for selecting sites for artificial ground water recharge.)

Figure 2, in Appendix 1, has been included to indicate a technical approach to estimating the rise and fall of a ground water table. Performance tests and monitoring of selected wells are also important indicators of the aquifer characteristics.

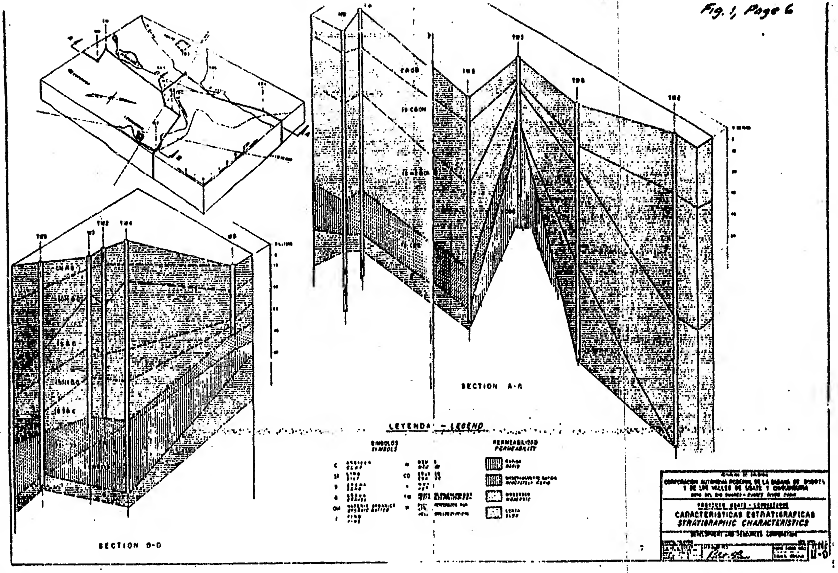
An electric logger can be used to determine information on substrata characteristics and permeability, although this approach is not recommended for Afghanistan, at least at the present time.

Information obtained above will indicate the feasibility of not only using shallow and other wells, but also using relatively shallow infiltration galleries (collector drains) or interceptor ditches. It will guide the locations and types of wells used, including hand-dug wells (particularly for small farms and the rural poor). Figure 3, Appendix 1, shows a typical design of a hand-dug well. The approach given above is an economical one that may be used in many agricultural or potential agricultural areas to obtain essential data for the conjunctive use of surface and ground waters.

2. Karezes.

Figure 4, page 7, shows a cross section of a karez. In specific regard to the use of karezes (additional karezes have not been recommended by Afghans), it is suggested that consideration be given to enlarging the tunnel where it contacts ground water, at A in Figure 4, or use a relatively small interceptor there across the tunnel, only if the additional water could be used effectively for farming.

Fig. 1, Page 6


SECTION A-A
SECTION B-B
LEYENDA - LEGEND
SIMBOLOS
SYMBOLS
PERMEABILIDAD
PERMEABILITY
CARACTERISTICAS ESTRATIGRAFICAS
STRATIGRAPHIC CHARACTERISTICS

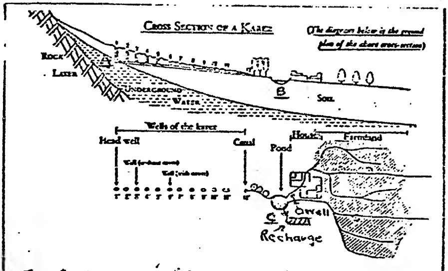


Fig.4-From report by Masatoshi Konishi, Tokyo 1969

Fig.4-Karez-A, head tunnel, contacting ground water; B, outlet; possible hand-dug well and recharge

Fig.5-Manometer equipped infiltrometers & soil moisture device (A) to measure movements of water in soil.

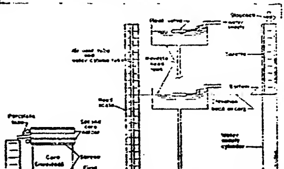


FIG. 6-Permeameter for determining various soil-water movements.

The movement of groundwater into a tunnel is directly proportional to the contact area. However, before attempting to increase the flow of a karez it should be determined if this will reduce the flow in a neighboring karez.

Water from karezes, outlets at B, Figure 4, water wasted at B, should be considered for artificial recharge. Recharge generally could be practiced slightly downstream and around or near a shallow well (usually hand-dug), C. Figure 4. Whether or not the recommendations concerning karezes are feasible at a given location depends on the characteristics of the site. This approach may permit farming more land.

3. Infiltration Galleries

An infiltration gallery is a horizontal permeable conduit or ditch for intercepting and collecting ground water by gravity flow and is quite widely used (not used in Afghanistan). To be successful it must be located in a permeable aquifer with a high water table and fed by an adequate nearby water source of suitable chemical quality (parallel to rivers, sub-systems, conveyances where depths of 3 to 7 meters are common, greater depths usually are not economical). Water entering a gallery or ditch flows to a collection sump where it is pumped for use. Based on a field trip, suitable sites appear available in Afghanistan.

For economy, an interceptor ditch sloping downward into a distribution system providing water for irrigation can be visualized if conditions are right. Small check dams (such as wire-and-rock dams) may be needed to reduce velocities in the ditch.

Yields vary widely, but rates up to 300 liters/sec/300 meters of gallery length are not unusual. Further field investigations of potential use are necessary.

4. Springs - to increase flow from springs (as enlarging exit) requires investigation.

ARTIFICIAL RECHARGE OF GROUND WATER AND DEVELOPMENT

Interest in artificial recharge has been expressed by Mr. Asimi, President, Planning, Department of Water and Power; Dr. Asefi, President, AgBank; and Dr. Raouf, President, Water and Power Engineering Co. Artificial recharge is not practiced in Afghanistan.

Artificial recharge means spreading water on land surface such as basins (formed by ridges around land surfaces) or small check dams (such as wire-and-rock) in wide, shallow river or sub-system with perm-

eable beds. Injection methods of recharge includes the use of pits, shafts, and ditches or meandering canals in permeable soil.

To use additional ground water by installation of wells where there is not enough natural recharge can be hazardous. The ground water table will decline, wells will have to be deepened, lift costs increased. This had happened in the area where the writer lives (the highly productive San Joaquin Valley of California, USA). More and more artificial recharge is practiced, particularly during wet years when more surface water is available or where there is sufficient stream flow or flow is wasted or goes to less desirable places.

A quote from Mr. M. Said of the AgBank staff at a meeting held Nov. 27, 1978 follows: "A number of farmers want to return their pumps to the bank because their wells no longer produce water."

Devices Used to Evaluate Potential Recharge Sites

The evaluation of potential recharge sites and the selection of methods or systems of recharge depends upon relating characteristics of surface soil and substrata to water movements in soil, Schiff, 1964. Figure 5, page 7, shows devices already established for testing the surface soil for the best locations for recharge, Schiff, 1964. Clues are first obtained by using a soil auger to determine where surface soil and shallow substrata are permeable.

The first step in selecting sites for artificial recharge in areas where recharge is needed is to bore holes with a soil auger in likely locations. This determines whether or not the soil and shallow substrata have the moderate to high permeability required, particularly for surface recharge. Site(s) need not necessarily be on the land being farmed but can be above where the slope of the ground water table is toward the farming area.

After possible sites have been determined, the next step is to use about three manometer-equipped infiltrometers and a soil-moisture device described by Schiff, 1964. These devices (marked 1, 2, and 3, supplied with water from a metal drum) are shown in Figure 5. The covered metal cylinder, marked "A" in Figure 5, is the soil-moisture device. The devices are simple and inexpensive and are used to determine the infiltration curve with time (entry rate of water into the soil), transmission rate (actual velocity of water, primarily in the gravity or non-capillary soil pores) hydraulic conductivity of the soil (ability of soil to transmit water), soil field capacity (amount of water held in the capillary or small pores), and soil saturation (total water held by soil when both capillary

and non-capillary pores are essentially full of water). A copy of the publication referred to above has been left with AID/Afghanistan.

The devices described above are used to test water movements in soil with a minimum disturbance of the soil, so that the natural forces existing, primarily capillarity and gravity, are operative. Figure 6, page 7, shows a permeameter, designed by Schiff, 1964, for obtaining information on water movements in soil as described above. The device uses soil cores obtained in the field by using a lever device to force thin-walled metal tubes into the soil. There is some disturbance of the soil but it is recommended over the "disturbed" type soil sample.

Methods of Artificial Recharge Include:

Surface spreading methods utilize basins, furrows, ditches, "wild flooding" and streams, check dams (example, wire-and-rock dams) in streams that are wide and shallow and the soil is highly permeable. Injection methods are also used employing gravel-filled shafts (with sand filters), pits and trenches. Wells are used sometimes, but this approach is not applicable to Afghanistan.

The basin method is illustrated in Figure 7, page 11. It consists of a series of interconnected basins formed by low earth ridges or dikes (can readily be done by farmers). Grasses may be grown on spreading basins to increase the infiltration rate or entry rate of water into soil. One of the best used in California is Bermuda Grass (appears applicable here). The grass cover maintains an open friable surface soil of good structure and infiltration rates of 1.2 meters per day were obtained even with considerable sediment in suspension in the water being spread. The infiltration rate, using similar water on a nearby basin with no vegetation, was about 0.4 meters per day. Figure 8 shows a rise of about 2 meters in the ground water elevation in 12 days of basin recharge (neutron probe).

Another possibility, although recharge is not as great, is to use a crop like alfalfa on spreading areas (called replenished irrigation in the United States). Alfalfa can take a lot of water and also provide a cash return by yielding several cuts as a food for livestock. However, this method (as does Bermuda Grass to a lesser extent) permits recharge plus a cash return. An injection method of recharge, such as a pit dug to expose aquifer material, may be used in basins where conditions are feasible.

As water infiltrates into soil the infiltration rate curve will decline as shown in Figure 9, page 11. The initial decline is largely due to swelling

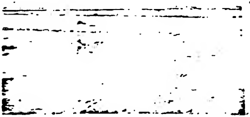


Fig 7- Surface recharge with ridges forming interconnecting basins, with Bermuda grass cover

Fig 10-Injection recharge, pit excavated to uncover permeable sand at a depth of 2 meters

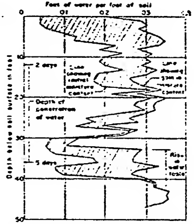


FIG. 8- Change in soil moisture after spreading water for 12 days in basin at Woodville, Calif.

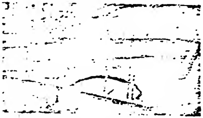


Fig.11-Injection recharge, pea-gravel, back-filled shaft (1.2m diameter) with 15 cm sand filter

Fig.12-Injection recharge ditches (may be connected) to expose aquifer material

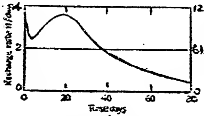


Fig 9 -Infiltration or recharge, entry rate of water into soil surface

Fig 13-Surface recharge, wire-and-rock small dams, wide shallow stream (permeable

of soil particles and some movement of soil particles; the recovery is due to the elimination of entrapped air; the final decline is due to clogging and microbial activity if a food substance is available in the soil for bacterial activity. Drying causes a recovery in infiltration rate, hence the wetting of some basins while others are being dried for recovery in infiltration rate.

Injection methods such as pits, shafts and trenches may be used where the topsoil, the subsoil and/or upper strata limit infiltration rates into aquifer material. Results from an experimental pit, Figure 10, page 10, were reported by Schiff, 1956. The sand exposed is two meters below the soil surface. The overall area of the pit is 0.405 hectares and the sand aquifer is 0.014 hectares. Rates up to 17.7 meters per day were achieved, (compared to 1.2 meters for the topsoil) or about 2.48 hectare meters per day. For the technically inclined, computations for velocity and hydraulic conductivity are given in Figure 14, Appendix 1.

Gravel back-filled shafts placed in channels may be used if characteristics so dictate, Schiff, 1956. A square wooden frame with a screen is placed over each shaft. Sand is placed in each frame or box. The sand filters out sediments that would normally go into the shaft. Occasionally when water is not in the channel the deposits on the top of the sand filter are scraped and removed. Figure 11, page 10, shows an experimental shaft with sand filter. Another approach is to back-fill the shaft with small gravel to about 15 cm from the top and then fill to the surface with sand.

Other methods of recharge include a canal that meanders in permeable soil or a series of ditches, Figure 12, page 10. Figure 13, same page, shows small wire-and-rock check dams used in a wide, shallow stream with a permeable bed.

The recharge method or system used will depend on information obtained using approaches described in discussing key Figures 1 and 5.

With the information now available to the writer, the grassed, interconnecting, basin method appears to offer the most potential for recharge in Afghanistan. Perhaps pits or shafts backfilled with sand at the end of each or some of the basins, may be a desirable addition. The method(s) or systems selected depend on the soil and substrata characteristics. Bermuda grass has increased rates in basins from 0.4 to 1.2 meters per day and assimilated "reasonable" sediment loads. Recharge irrigation using alfalfa on basins would provide less recharge, but a food for livestock. Here the combination with pits or shafts at the end of each or some basins may be a good approach to increase recharge.

Water Used for Recharge

It is usually desirable to avoid spreading water from initial high runoff flows of rivers or streams as such flows contain considerable sediment in suspension. However, diversions or pumping (includes floating pumps) from the upper part of the flow avoids bedloads and thus much of the sediment.

Since excess surface runoff, generally of good quality is used for recharge, there is a dilution of salinity of the ground water. This is an important benefit of recharge.

Work by Farmers

Farmers could do the work required for shallow wells and construction of recharge methods and systems with little supervision after sites and approaches are selected. The interest of farmers in the use of ground water has been attested to, work suggested herein provides more assurance of success in using ground water.

Ground water is usually a supplementary supply to surface water in conjunctive use, although in the highly productive San Joaquin Valley of California about 60 % of the irrigation water comes from wells (more and more artificial recharge is practiced there). There are many locations in the United States where ground water is the main supply of water for irrigation.

Management

It is necessary that farmers maintain wells and equipment and recharge facilities. Extension service agents and extension workers could provide necessary information. Management is necessary to maintain ground water at "safe elevations" through proper use and recharge. This will minimize the negative effects of years of low surface runoff and droughts (includes training of farmers, technicians, and extension workers).

LITERATURE REVIEWED OR CITED

Agricultural Development Bank Project, Afghanistan Well Test and Site Report, 1973.

Azimi and McMillan, Report on Ground Water Development, 1977

Diagnosis and Improvement of Saline and Alkali Soils, United States Salinity Laboratory Staff, Agriculture Handbook No. 60, USDA 1954 (an updated version pending).

Ercon Engineering and Resources Consultants, Hydrological Investigations of the Hari Rud Basin between Marwa and Ghuryan, Afghanistan, Phase I and II Reports, January 1973, December 1974.

Jones, R. J., U.S.G.S., Program of Ground Water Resources Investigations for the Helmand-Arglandab Valley Authority, Afghanistan, Administrative Report, LashkarGar, Afghanistan, December, 1971.

McClymonds, N. E., Shallow Ground Water in the Zamin Dawar Area, Helmand Province, Afghanistan, U.S.G.S. for U.S.AID, Jan. 1972.

Rendell, A. & others, Ground Water Reconnaissance in the Aughandab River Basin near Kandahar.

Sammel, E. A., Ground Water Reconnaissance in the Arghandab River Basin near Kandahar, U.S.G.S. for U.S.AID, December 1971.

Schiff, Leonard, Devices for Measuring Soil-Water movement in Designing Recharge Facilities, Trans. Amer. Soc. Agr. Engrs., Vol. 7,1964.

Schiff, Leonard, Ground Water Recharge Hydrology, No. 3 Issue Ground Water, Vol. 2, July 1964.

Schiff, Leonard, Ground Water Recharge Methods based on Site Characteristics and on Sediment in Flood Water, International Comm. on Irrigation and Drainage, 5th Congress, R.Z.

Schiff, Leonard, the Darcy Law in the Selection of Water Spreading (Recharge) Systems, Symposia Darcy, Dijon, France, 1964.

Svendsen, M.T., Some Aspects of Irrigation Technology in Afghanistan, 1977.

United Nations, Survey of Land and Water Resources, Afghanistan, Vol. II, Geology, Food and Agriculture Organization, Rome, 1965.

United Nations, Ground Water Investigation, Afghanistan, Vol. 1, Development Programme, Vols. 1 & 2, New York, 1972.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to the several staff members of U.S. AID/Afghanistan for their discussions concerning the work, suggestions, and for their arranging of meetings between Afghans, Aid personnel and consultants of Experience, Inc. This developed a close working relationship amongst all, both professionally and personally, and did much toward making the work a cooperative endeavor.

Dr. Raymond Fort, guiding the program for U.S. AID and consultants, constantly worked to further the team's assignments, and his personal cooperation and friendliness meant much to the team's efforts.

The team was assigned a secretary, Mrs. Virginia Alfsen, who not only handled our work rapidly and efficiently, but was always cooperative, courteous and pleasant. We were fortunate in having her with our team.

In regard to the Afghans, the Ministers and their staffs, and others off and on the AID base, one is left with a good feeling about their cooperation, friendliness and earnest efforts to help their country and the team. They are a wonderful people and one wishes them well in their endeavors. It has been a pleasure working with them.

A RECOMMENDATION

At one time the writer was Research Leader of an Agriculture Research Service project, U.S. Department of Agriculture, concerned with research both theoretical and applied, in determining the effect of the physical, chemical and biological characteristics of water and soil on water movement in soil and substrata, particularly as related to artificial recharge, but also applicable to irrigation and drainage. Three men formed a starting nucleus, a hydrologist (surface and ground water); a soil scientist (physics and chemistry) and a soil microbiologist (microbiology and soil). In time a few other scientists were added. Cooperators were the California State Department of Water Resources and the University of California at Davis.

Such a starting nucleus (possibly adding an irrigationist) of Afghans to study water and soil resources, and relationships mentioned above is recommended for Afghanistan. It could be a cooperative effort of some of the Ministries. This will produce information on natural resources and irrigation invaluable to increasing agricultural production in Afghanistan. At the start, such an effort could be aided by trained scientists in these fields from another country.

IRRIGATED SUB-SECTOR ASSESSMENT

Annex 1

Use of Ground Water and Recharge
to Increase Agricultural Production

APPENDIX 1

Approx. approach for sq. area of 26 ac. ($P = 4{,}256'$; $s = 1064'$)

Water entering soil in 30 days = 780 a.f.

Soil between F.C. & F.S. with $h = 100'$

Water in transit $100 \times \frac{2}{2} \times 26 = 260$ a.f.

Assume H reaches 50' with 0.1' more water in water table or $50 \times .1 \times 26 = 130$ ac. ft.

Water flowing laterally = $780 - 260 - 130 = 390$ ac. ft.

Lateral flow (q_L) for 1' of perimeter

$\frac{390 \times 43560}{4256} = 4{,}000$ cu. ft.

$q_L = t K \frac{H}{R_L} H (1) = t K \frac{H^2}{R_L}$ --- (1)

$4{,}000 = 30 \times 50 \frac{H^2}{R_L}$

$R_L = \frac{1{,}500}{4{,}000} H^2 = \frac{H^2}{2.67}$ --- (2)

Mound storage for unit lateral flow

$q_L = \alpha \frac{H R_L}{2} (1)$ ------ (3)

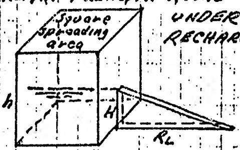
or $H R_L = 40{,}000$ c.f., substitute value for R_L from (2)

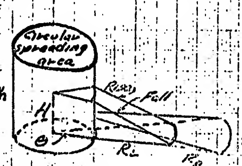
$H \frac{H^2}{2.67} = 40{,}000$; $H^3 = 107{,}000$

$H = \underline{48'}$ (close, OK)

Substitute $H = 48'$ in (2) and $R_L = \underline{860'}$

HEIGHT & LENGTH MOUND UNDER RECHARGE





Conditions: square or circular spreading area = 26 acres.

Infiltration rate (f) of surface soil (loam) measured as 1'/day

Hyd. Cond. (K) of underlying sand (down to impervious layer at depth (h) 100') = 50'/day

Time t = 30 days

Porosity α (F.S. − F.C.) measured $50\% - 30\% = 20\%$

Take $\theta = 10°$.

K assumed equal, all directions

Approx. approach for circular area (A) of 26 acres ($r = 600'$)

Water entering soil (as before) = 780 ac. ft.

Water in transit (as before) = 260 ac. ft.

Assume $H = 45'$ with .1' more water in water table or $45 \times .1 \times 26 = 117$ ac. ft.

Lateral flow = $780 - 260 - 117 = 403$ ac. ft.

Lateral flow thru arc (formed by θ)

$403/36 = 11.2$ ac. ft. or 488,000 cu. ft.

$q_L = t K \frac{H}{R_L} H \left(\frac{\pi r \theta}{180}\right)$ ---- (1)

$R_L = t K \frac{H^2}{q_L}(105) = \frac{30 \times 50}{488{,}000} \frac{H^2 (105)}{} = \frac{H^2}{3.1}$ (2)

Mound storage for unit (θ) lateral flow:

$q_L = \alpha \frac{H}{2} \left[\pi \frac{(R_L + r)^2}{360} \theta - \frac{A}{N_s}\right]$ --- (3)

$488{,}000 = .2 \frac{H}{2} \left[\frac{(R_L + 600)^2}{11.46} - 31{,}500\right]$

$H R_L^2 + 1200 R_L - 55{,}800{,}000 = 0$

Substitute $R_L = \frac{H^2}{3.1}$ from (2)

$H^5 + 3720 H^2 - 536{,}000{,}000 = 0$

TRY $H = 45'$; $184{,}500{,}000 + 7{,}533{,}500{,}000$ = 533,000,000 OK.

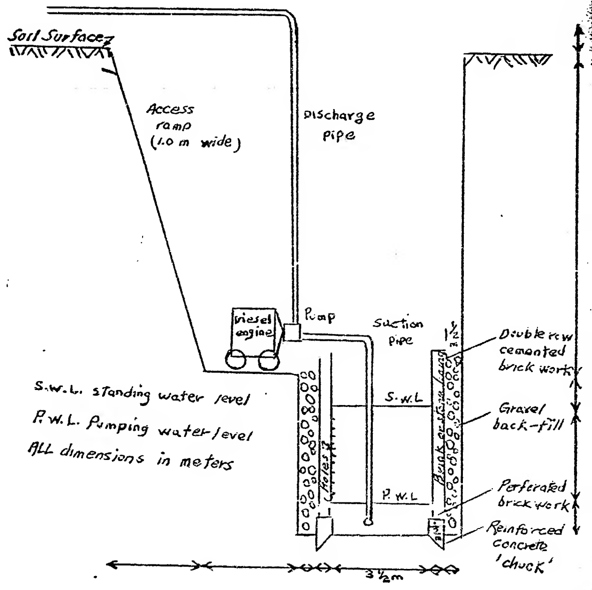
Sub. $H = 45'$ in (2) and $R_L = 655'$

$q_s - A_s \left(\frac{\alpha}{2}\right) h - H R_L \frac{\alpha}{2} = t K \frac{H}{R_L} H \left(\frac{\pi r \theta}{180}\right)$

$q_s - A_s \left(\frac{\alpha}{2}\right) D - H R_L \frac{\alpha}{2} = \alpha \frac{H}{2} \left[\frac{\pi (R_L + r)^2 \theta}{360} - \frac{A}{N_s}\right]$

FIG3 – DESIGN OF HAND DUG WELL SITE

AT



MIS GWD Subsec

Not to scale

Courtesy GWD Subsectio

The velocity of flow through the surface of the pit is

$$V = Q/a \tag{2}$$

where a is the area of the pit through which the measured rate of flow, Q, is moving. Using the initial rate of 2 acre feet per day, the average velocity

$$V = Q/a = 2/.0344 = 58 \text{ feet per day.}$$

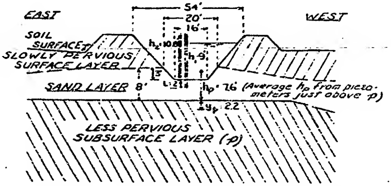


Fig. 7
Schematic diagram of Pit showing dimensions along East-West axis and datum points.

From Figure 7 the value of K for the sand becomes

$$K = \frac{VL}{(h_2 - h_1)} = \frac{58(2)}{(10.8 - 9.0)} = 64 \text{ ft. per day} \tag{3}$$

where h_2 is the height of water in feet in the piezometer which bottoms just above the sand h_1 is the height of water in feet in the piezometer which bottoms below the top of the sand and L is the length of the sand column between the bottoms of piezometers h_2 and h_1. The datum is the bottom of the piezometer measuring h_1 as shown in Figure 7.

Within a short period of time, water had spread out laterally in the sand layer beneath the pit over the less-pervious soil layer underlying the sand. When equilibrium for the system was approached, this lateral spread of water covered an area (a_p) equal to 1.8 acres. The average velocity of flow, V_p, through the less-pervious layer, p, below the sand of area $a_p = 1.8$ acres was

$$V_p = Q/a_p = 2/1.8 = 1.11 \text{ feet per day} \tag{4}$$

From the Darcy law, K_p, the permeability of p can be approximated by equation (1) as follows

$$V_p = K_p(h_p + y_p)/y_p \tag{5}$$

where h_p is the average pressure head on p, as determined by piezometers within and outside the pit, and y_p is the average length of the saturated column within p, as approximated from work of SCHIFF (1953). Substituting the value of V_p from (4) in equation (5)

$$K_p = \frac{1.11}{(7.6 + 2.2)/2.2} = 0.25 \text{ foot per day}$$

This K value is consistent with that previously shown for untreated soil.

The decline in infiltration rate for the pit between the first and second runs, marked 1 and 2 on Figure 4(A), may have been caused by the disruption of filtered material within the pea gravel and on top of the sand. The change in pressure due to variations in head may have caused shifting of filtered material and more severe clogging of the sand surface. It

THE POTENTIAL IMPACT OF "TECHNICAL PACKAGES" IN GROUND WATER EXPLORATION AND INVENTORY, DEVELOPMENT, AND RECHARGE 1/

BY

Leonard Schiff, P.E.

Consulting Hydrologist and Agric. Engr.

Before discussing ground water technical packages it will be helpful to consider what is happening in Afghanistan. Some statements made by Afghans follow and are revealing: "there is insuffcient water (yet runoff is wasted to deserts and swamps), increase the supply of water by using more ground water (particularly shallow wells), increase yield of existing karezes and use their waste flows, improve distribution and management of water." Quotes from a few Afghans from Ministries follow: Mr. Said, Ag Bank, "a number of farmers want to return their pumps (to Ag Bank) because their wells have gone dry"; Mr. Asifi, President of the Ag. Bank indicated at a meeting that more wells are needed but should be based on a sound development program (it seemed he stresses shallow wells, although did not rule out deep wells, largely to help the rural poor); Mr. Azimi, President of Planning, Dept. of Water and Power mentions in a report "the importance of timely ground water development, points to ground water as often being the most reliable source of irrigation water, aquifers as reservoirs to improve agricultural production and cost savings when compared to surface reservoirs, ground water supplies must not be neglected he states, and <u>recommends artificial recharge</u>"; (Artificial recharge is not yet practiced in Afghanistan).

The M.I.S. concluded that a potential for ground water development exists and that farmers are interested, (but want more assurance of success). Dr. Raouf, President Water and Power Engineering Co. along with two members of his staff stated that they are developing plans for three areas and are concerned about the possible decline in ground water tables as pumps go in.

Potential Impact of "Technical Packages" in Ground Water--with the foregoing in mind the technical packages involving ground water may be divided into three parts, namely: (1) <u>Exploration and Inventory; (2) Development; and (3) Artificial Recharge</u>. A description of items (1), (2), and (3) follows: (1) <u>Exploration and inventory</u>: Ground water levels are declining in a number of farming areas as attested to by the statements given above and the call for artificial recharge. It is <u>now</u> imperative to determine the physical and chemical characteristics of existing ground water basins that are being used, on a priority basis, stressing areas with a large number of farmers and rural

---

1/ Accompanies "Irrigated Sub-sector Assessment" Annex 1 entitled "Use of Ground Water and Recharge to Increase Agricultural Production by Leonard Schiff, Kabul, Afghanistan December, 1978

poor (80-85 % of the people make their livelihood off the land). To augment information that now exists on logs, profiles and well tests, portable, small-bore, test, drill rigs should be used in strategic locations. From this information stratigraphic characterisics may be plotted (texture of sub-strata, particularly aquifer material, its depth and extent), depth and extent of ground water, quality of ground water noted, present use related to the amount that can be extracted "safely", and the effect of ground water recharge estimated (using surface runoff during periods of excess).

Technical Assistance: test hole sites should be selected by a ground water hydrologist based on existing data and inspection of selected farming areas. Technically-trained Afghans should accompany the hydrologist as part of a training course; commodities needed are containers to collect soil and water samples at significant changes in substrata, a small kit for testing water quality, such as salinity and alkalinity, and some sieves. Equipment includes small-bore, test, drill rigs. A rig with tow car costs about $12,000 (a three-man crew is needed for each rig, however one rig can cover an appreciable area in a relatively short time), financing could come from credit and/or reimbursement.

The potential impact would be far reaching: proper location of wells, types and optimum depths and spacing of wells, Approximations could be made of yields to be expected, effect on water table estimated and amounts of recharge needed.

(2) Development: At present there are numerous wells, karezes, and springs being used in Afghanistan that have additional potential for development of ground water. The writer also recommends consideration of Infiltration Galleries and ditch interceptors, and has stressed the need for artificial recharge. The potential impact mentioned above applies here. Also karezes waste a great deal of water particularly during non-irrigation periods, this water could be used for recharge in many areas as a supply for shallow well(s). Springs may be developed to yield more water where conditions warrant. A field trip revealed good possibilities for considering Infiltration Galleries or interceptor ditches. A ground water hydrologist using a soil auger could determine potential after establihing the gradient (slope of water table) and hydraulic conductivity (ability of soil to transmit water). Consideration could be given to putting an interceptor across the head of a karez (at the bottom of the Mother Well) to increase flow for additional farming if it is found desirable and feasible in a given location. This would be based on existing data and on minor tests. Technically one or two Afghan technicians could work with the hydrologist for training. Equipment would be small, portable, and inexpensive. Financing, although relatively little would be required, could be by credit of reimbursement.

(3) Artificial recharge is a must in the writer's opinion, as present natural seepage or unintentional over-irrigation are not arresting the decline of ground water tables in many areas (or the decline that will occur as more wells go in). Artificial recharge simply means putting excess runoff water underground, now much of it wastes to deserts, swamps or less desirable places. Recharge

is accomplised by surface methods (such as grassed basins, formed by simply building ridges around land surfaces) and by injection methods (pits, gravel backfilled shafts with sand filters, ditches) or combinations of surface and injection methods. Another approach i$ over-irrigation of a crop like alfalfa grown on basins (with or without a pit or some injection method, based on characteristics of the site). This provides a two-fold benefit--recharge and a cash return or food for livestock. Equipment used include: (a) equipment or results under (1) above , exploratory and inventory and a few manometer-equipped infiltrometers and a small moisture measuring device (all simple, quickly used equipment of low cost), and possibly to save laboratory work, a small portable oven. (b) The equipment and approaches could readily be used by technicians who would accompany the ground water hydrologist at the start. Here again sites should be selected by a ground water hydrologist at least at the start of such a program. (c) The small amount of financing that would be required could be by credit or reimbursement. The writer considers the use of ground water and recharge a must for Afghanistan to increase agricultural production in the short and long term. Details of much of the foregoing is discussed in Annex 1, attached to the overall section on Irrigated Sub-Sector Assessment.

Dec. 5, 1978

ANNEX 2

IRRIGATION SUB-SECTOR ASSESSMENT

The Role of Soils in Land Development to Increase Agricultural Production

by

Dr. M.K. Radwan
Soil Scientist
Experience Incorporated

Kabul, Afghanistan
December, 1978

ANNEX 2

TABLE OF CONTENTS

I. INTRODUCTION

As a result of technical meetings, review of available data and field trips, this Annex, "the Role of Soils in Land Development to Increase Agricultural Production" was prepared.

Afghanistan depends mainly upon agriculture for its economy. While there is more than one Ministry to deal with water, soils has been left as an "orphan" with very low voice within both the Ministry of Agriculture and the Ministry of Water and Power. Consequently, little attention has been given to soils since FAO has completed the land survey in 1963. Since then soil activities have been confined to a very few localized surveys for project development. The lack of recognition and the understanding of the fertility aspects of the soil in Afghanistan has resulted in the deterioration of the productivity of the land, spread of salinity and alkalinity, and decrease in fertility due to poor management in all aspects.

Therefore this annex focuses on the role of soils in land development to increase production in Afghanistan, and mentionsat least these main areas in the methodology of this presentation:

- The general description of the soils in Afghanistan - so that their potential in natural resources can be recognized, and their relative quantitative effect can be evaluated in project development.

- The second main area deals with the management and the fertility aspects of soil to increase agricultural production. The decrease of fertility levels and increase of salinity and alkalinity and fertilization are among the subjects treated in this context.

- The third area deals with the role of soils within the farm infrastructure, and farm practices. Soil-plant-water relationships are a[illegible]vered.

- The fourth area described is the soil laboratories which are the only tools left to look into that subject. They point out production capabilities of the soil, diagnose the defects and prescribe the remedial measures. Establishment of a salinity laboratory is considered vital.

- Finally, the report suggests certain corrective measures related to each of the above areas and suggests projects or programs to remedy the situations as solution interventions. Research training and extension are also included.

II. SOILS

A. General Physiographic Features

The streams of the country run in long or short narrow or wide valleys separated by hills and ranges. These valley soils are of alluvial, colluvial or mixture origin and are calcareous and non-calcareous. The texture varies from coarse, medium and loamy and have varying depth, a few have heavy texture. In most of the cases the internal and external drainage is good. In general, there is a distinction of three terraces, i.e., terraces, foothill areas and plains. This type of formation leads to different soils. Consequently their management should also differ. Soil properties are different and their suitability for different types of development is likewise different. Many soils show distinct degrees of salinity especially those in the low lying areas.

In all areas, there is a variable portion of the valley land that would benefit by additional irrigation should the water be available. There are also a great many irrigable soils that are badly managed or have deteriorated and in which high water tables and patches of salinity are widespread. It was observed that if soils upstream are added to the irrigated land, the lower reaches of other valleys might turn saline or if they are now intensely cultivated they may deteriorate unless proper management and drainage are considered.

In some cases a gravelly layer can be seen in areas right on the foot-hills whereas in other cases gravel forms the valley bottoms. Soils with these characteristics are not suitable for irrigation. Possible alternate use as pastures should be considered. There are also areas which show certain limitations which if corrected would put the soils in a higher class of productivity or make them suitable for irrigation.

In other instances where the elevation is high and coupled with fairly logical gradient, the valley is physically divided into 2 or 3 soil varieties. The upper land is cultivable for intensive agriculture, and the middle land is probably cultivable also; however, the lower portions will be at the mercy of the intensity of the flow. Consequently the cultivation and production patterns are varied among the three soil identities, and each one also varies with respect to time.

One encounters soils that are saline to a preventative degree to cultivation, and others in which salinity is somewhat tolerable and yet others in which only patches near settlements could be cultivated.

Some valleys are characterized by very recent immature soils and in order to irrigate these soils, especially in narrow portions, infiltration galleries (karez) and wells are used. Erosion has decreased the irrigability of these soils. Their suitability for cultivation is thus limited to low water requirement and salt tolerant crops.

Some saline soils being a part of a tectonic basin have internal drainage. These can be added to agricultural development if an underground water scheme can be launched to irrigate them and reduce their salinity.

Some fans like the Farah River alluvial merge into the saline and gravelly desert north of the Helmand Depression. There are indications that cultivation formerly extended over large areas that are now saline. Better water management and soil reclamation practices are needed to increase the cultivable area.

Some basins can be cultivated with more profitable crops, but are used only for pasture at present, while others can be more profitable if only restricted to pastures.

In some large valleys, cultivation is found to be confined to its terraces as the surrounding slopes are composed of stony material or outwash fans. Deep valley soils derived from alluvium, colluvium and loess can be very well cultivated. Sometimes the quality of water is the limiting factor unless the soils have good internal drainage. In these cases, if an intensive program of cultivation is adopted, improved drainage and land management programs must be followed.

B. Land Classification

Certain wadies or valleys were surveyed in Afghanistan by an FAO reconnaissance team in 1963. The soil classifications were based on relevant soil characteristics including the morphological features of the soil profile, the thickness and texture, the nature of the underlying materials, rate of percolation and water holding capacity, degree of salinity, erosion, slope and susceptibility to floods.

The following soil classes of the surveyed areas are as given in Tables A2-1 and A2-2:

I. Very suitable for irrigation
II. Moderately suitable for irrigation
III. Marginally irrigable land
IV. Non-arable, not suitable for irrigation except under special conditions, for irrigated pasture
V. Non-arable, undermined suitability for irrigation
VI. Non-irrigable land.

The above six classes are subdivided to include these subclasses as limitations:

- Limitation due to salinity
- Limitations due to texture, depth, permeability and/or inherent fertility
- Topographic limitations such as steepness or irregular slope and erosion
- Wetness, drainage or flooding problems and a high groundwater table.

C. Inventory and Classifying Soils

In agriculture, water and soils participate in plant growth and crop production. Water can be identified and measured or approximated in Afghanistan, while soils are not well described and identified as a natural resource. Soils as a medium for plant growth are the limiting factor for water usage and crop production.

The quantitative and qualitative chemical and physical properties of the soil determine its productive potential. The determination of these properties is required to program nutrient requirements for different plants, orchards and trees with plant feeding material. The lack of these nutrients will cause plant deficiencies, however they can be replenished by fertilizers. The physical properties of the soil play a determined role in water regimes in land use.

The evaluation of the relief, topography, stratification, texture and structure is essential for land and soil utilization before investment in development can be made. They may be limiting or prohibiting factors in the development of the land when it is put under cultivation.

There is a difference between land use and suitability of the land. The land can be used for a given crop, but may probably suit the production of better cash crops, fruit trees or orchards. This has never been determined in the country.

Properties of the land are needed for hydrology groundwater study - roads, construction, cities, farming, factories. The magnitude and extent of its properties decide its future usage. Soil surveys are meant to identify soils of same properties together. Surveys have different degrees to identify soils of same properties together. Surveys have different degrees of refining and detailing. They are reconnaissance as those made by the FAO in 1963, semi-detailed for project identification and feasibility studies, or detailed for project execution. Specific surveys are tailor to specific objectives such as reclamation surveys, and suitability to specific crop surveys, etc. Table A2-2 illustrates the basic triangle used in soils classification.

After soil survey comes the capability classification - criteria for soil capability classification is different from location to location.. Following the capability classification is the soil evaluation or value.

In Afghanistan only a broad reconnaissance soil survey that is not adequate for judging soil potential is made for certain localities or wadies. It is too general for definite conclusions or agricultural development. As a result, the inventory of the main and only critical component in the national wealth of the country has not been determined. Consequently, any planning is not judged properly. The fact that some ocassional localized surveys are made with certain depth does not substitute the need for at least the capability soil survey, nor does it quantify the wealth of the soil as a natural resource and as a limiting component in agricultural production in Afghanistan. If time does not allow the execution of a detailed survey, the least that needs to be done under the circumstances is a short term soil capability classification to determine with a considerable degree, the most suitable land for agricultural projects and to insure our success in agricultural development. This quick capability survey can be carried out in less than a year. It is meant to evaluate the main parameters of potential among the different soil bodies.

D. Some Soil Physical Properties and their Determination

The following are three main points related to soil water properties:

1. Infiltration rates for the main soils in Afghanistan lie within these categories:

    a. Loamy textured, light medium soils, reflect good permeability, easily and rapidly absorb the water applied on the surface during irrigation period. They conserve water if there

is an adequate supply for the normal growth of the crop.

b. Heavy textured soils which are low in organic matter in the upper horizon, have low permeability. In contrast, light sandy loams or sandy soils will let the moisture move quickly through the soil mass below the root zone into lower horizons. This is one of the main physical points to consider. Examples of this are the soils of the northern parts of Chazni and Jilga Valleys.

The infiltration rate for 5 hours was measured at .37-.38 mm/minute, then falls to .29 and remains steady. Loamy non-saline soils in this region have more organic matter than many other parts of the country. This can indicate the suitability of these lands for development. Some higher filtration rates can reach .45 mm/minute.

Infiltration rate for salty soils differs from the non-salty soils for the given class texture they belong to.

2. Field capacity of the main soils are also expected to vary within the country. The heavy textured loams with low organic matter content and non-saline soils will show low field capacity.

The field capacity for loamy soils in Afghanistan is in the range of 21-23% (on dry weight basis). Light textured and non-saline soils have lower field capacity ranging from 16-18%, while salty soils and fine textures show it generally high. Loamy soils are characterized by higher field capacities 23-32% (due to salt hygros capacity of $NaSo_4$, $MgCl_2$, $CaCo_2$, etc.).

3. Volume weight: Normal soils show volume weight to be 1.34 - 1.35 gm/cm^3. This degree of compactness allows for air and water permeability as well as for a microbial process. If the volume weight values increase with depth the soil will have an unfavorable effect, say if it goes to 1.40. This results in a reduction of pore space, and consequently does not allow the moisture to move properly through the soil mass. This can result from repeated plowing to the same depth and from irrigation.

Volume weight in the soils of Afghanistan can vary from 1.25 - 1.6 or sometimes 1.7 gm/cm^3. This high compaction reflects clay content in the soils and a high mineral content. Volume weight is lower in the salty horizon than in the rest of the profile.

Volume weight in the soils of Afghanistan can vary from 1.25 - 1.6 or sometimes 1.7 gm.cm3. This high compaction reflects clay content in the soils and a high mineral content. Volume weight is lower in the salty horizon than in the rest of the profile.

Water storage capacity cu m/hec.:

	0-50 cm. depth	0-100cm. depth
Farah Rud	(1428-1628)	2868-3168
Hari Rud	1485-1702	2939-3537

4. Determination

   a. Soil permeability determination to be performed in sites maintaining a constant head of water within two cylinders concentrically placed on the surface of the soil.

   b. Field capacity should be determined on a flat plot of soil 2m x 2m, apply water at the rate of 2000 cu m per hectare. The plot surface is protected from evaporation - within 2 to 4 days depending on the soil texture, soil samples are taken for moisture determination for successive layers 20 cm. each to a depth of 1 to 1.5 m. made by standard methods

   c. Volume weight preferred to be determined on undisturbed soil sample by using a small metal cylinder of 100 cm^3 capacity.

III. SOIL PRODUCTIVITY CAPACITY

A. Quality of Soil and Water

In most of the lands in Afghanistan the quality of either the soil or the water or sometimes both, is not good enough to produce an optimum yield without the adoption of reclamation measures or special management practices. Salinity and alkalinity are among these unfavorable land characteristics responsible for this requirement. In addition the deterioration of agricultural production on previously productive lands is mainly attributed to the development of salinity and alkalinity.

The lack of awareness of the problems of salt affected soils where conditions permit their formation and of necessary reclamation measures is one of the main factors for the failure of irrigations projects; however, early prediction of these hazards helps the timely setting up of land protection programs.

Successful programs must be based on knowledge of the factors involved in the formation and development of salt affected soils and on the adoption of a good methodology.

These factors are natural and man-made. They are dependent on man to improve or worsen the situation in the land. They are functionally interrelated and thus should be treated in an integrated approach. These are:

Land Levelling

Land levelling is important for efficient water distribution by surface methods. Improper land levelling can create a micro relief; variation in depth and homogeneity of soil profile, and pulverization of the fine sandy material and changes in the soil structure.

Changes of the micro relief in the order of less than one foot of soil (30 cm.) will result in an increase of salt content in the raised spots and better leaching in the dips. The spotted salinity patches in poorly levelled soils are a result of that. With repeated land shaping before cropping and as the development of the land proceeds, the micro relief variation disappears. The changes in depth and homogeneity of the soil profile as a result of land levelling depend on topography, original soil depth, and nature of stratification and size of earth moving. Where shallow profiles or relatively less permeable layers are exposed close to the surface, the chances for development

of salt affected soils become much greater than in the case of deep and homogenous soils. Variations in soil depth are not easy to correct. Therefore improper land levelling operations associated with shallow profile formation should be given more consideration in soil management. Calcareous soils and fine textured profiles (high in silt content) are affected by land levelling. Pulverization of the soil material, breaking of aggregates and compaction alter the pore size distribution and decrease soil permeability. Such alterations would slow down water movement, reduce leaching of salts, encourage water logging, and consequently buildup salinity. Costly ameliorative measures have to be taken to correct these undesirable effects if improvement of aggregation and permeability cannot be achieved by normal cropping operation practices.

Tillage

This operation is carried out for numerous reasons including seed bed preparation and improvement of soil permeability. Tillage can increase salinity through its relationship with vertical distribution of salts, depth of tillage and soil stratification, soil moisture at time of plowing, tillage machinery and implements and timing of tillage.

Planting

Planting techniques and positions vary with type of crop and can be modified to overcome unfavorable conditions for germination and seedling growth. It might be most useful for Afghanistan to follow or test these following practices which indicate a decreasing order of harmful effects of salinity on plant stands:

- Plant on top of a single row bed
- Plant near edges of a double row bed
- Plant on side of a sloping bed
- Plant in irrigation furrows
- Broadcasting or drilling of seeds on flat fields followed by heavy irrigation

Soils of high alkalinity and salinity are characterized by low permeability and susceptibility to water logging. Row crops should be planted on high beds to reduce the harmful effect of water logging. The amount of seeds required for planting a given crop in a salt affected soil is higher than on a normal one. Also, a decrease in the percentage of emerging seedlings and a delay in emergence are to be expected.

Observations of the above relations would be helpful in the identification of the advancement of salinity and alkalinity problems. It would be valuable to keep records of the amount of seeds, percentage of emerging seedlings and time of emergence.

Mulching

This practice helps to reduce water lost through evaporation by disrupting capillary continuity on the soil surface. Generally, the effectiveness of mulching depends on the depth to water table, pore size distribution, climatic conditions and crop cover.

Fallowing

Under conditions where water is a limiting factor for crop production the land may be left fallow for some time; which is done to increase the soil water reservoir to benefit subsequent crops (as in dry farming), or until an adequate water supply is available (in irrigated farming). Measures should be taken during fallowing to reduce evaporation and consequently, salinization.

The effectiveness of fallowing depends on other factors including the depth of the water table, quality of groundwater, soil properties, climatic conditions, and length and frequency of fallowing. Evaporation from a dry surface of fine sandy loam, like many soils in Afghanistan, would proceed at a rate of about 8.3, if the water table is kept at 90 cm. and 1 mm/day when at 180 cm. This indicates the importance of the water table depth factor and the danger of fallowing where a shallow water table exists.

Fallowing should be considered for reducing water loss by evaporation, reducing salinity, as well as increasing salinity. In the latter case the depth and quality of ground water are the most important parameters.

Application of Manures, Fertilizers, and Amendments

Manure and fertilizer are added to soil to increase its productive capacity. Amendments are applied to correct the harmful effect of the physical and chemical properties of the soil.

Manuring improves the physical condition of the soil and enhances leaching of salts and drainage of wet soils. It also has a high nutritional value. In certain soils green manuring is very much recommended.

Fertilization is an important factor in crop production. The chemical compostion of fertilizers, solubility, rate of release and the methods of placement, especially in the early stages of plant growth are factors to be well understood in this connection, especially with regard to increase of salinity.

Crop Rotations

Factors governing crop rotation are mainly the availability and adequacy of soil and water resources, suitability of the crop to the prevailing climatic conditions and assurance of an economic return. In a reclamation rotation, the suitability of the crop to the soil and water qualities are very important. Under conditions that encourage salinization, crops should be selected on the basis of their salt tolerance and their effect on the salt balance in the soil. For alkali soils, these should be selected on their tolerance to the sodium ion and to the adverse physical conditions. Plants differ also in their water needs in quantity and frequency. Therefore, it is to be expected that salinity of the soil will be affected differently under different crop rotation and vice versa. For example, the salinity will be higher after a rotation of cotton - cotton, than after berseem-cotton-beans, or cotton-berseem-rice. Crops with a long duration of evapotranspiration will cause, in the absence of proper leaching practices, accumulation of salts in the root zone, while crops such as berseem, rice and others requiring frequent irrigation reduce salinity effectively, especially where there is adequate drainage.

Therefore, the knowledge of the salt balance under various crop rotations is very important in order to curb the increase in salinity or alkalinity. Continuous monitoring of salinity and alkalinity after each crop or at least a rotation not only creates awareness of a potential problem but also helps to re-evaluate the management practices associated with the cropping system. Crop performance and yield are good indices of the improvement or deterioration of the production inputs including soil conditions.

IV. SALINE AND ALKALINE SOILS

These sequential guidelines are bases for diagnosis and remedial measures in salt affected soils in Afghanistan.

A. Origin and nature of saline and alkaline soils

1. Sources of soluable salts
2. Salinization of soils
3. Alkalinization (accumulation of exchangeable sodium in soils)
4. Characteristics of saline and alkaline soils; saline soils; saline alkaline soils.

B. Determination of the properties of saline and alkaline soils.

1. Sampling
2. Estimation of soluable salts by electrical conductivity
3. Chemical determinations; ph, soluable cations and anions; soluble boron; exchangeable cations, gypsum, alkaline-earth carbonates
4. Physical determinations: infiltration rate; permeability and hydraulic conductivity; density and porosity.
5. Choice of determinations and interpretation of data; equilibrium between soluble and exchangeable cations; factors that modify the effect of exchangeable sodium on soils.

C. Soil management in relation to salinity and Alkalinity

1. Irrigation and leaching in relation to salinity control: irrigation; leaching requirement; leachin methods; leaching in the field and trials; special practices for irrigation to prevent increase of salinity.

2. Drainage of irrigated lands in relation to salinity control: Drainage requirements; water-transmission properties of soils; boundary conditions; layout and placement of drains; techniques needed for drainage investigations such as measurements of hydraulic head, determination of subsoil stratigraphy, determination of water-transmitting properties of soils.

3. Chemical amendments for replacement of exchangeable sodium: Solubility of various amendments under different soil conditions; soils containing alkaline-earth carbonates;

soils containing no alkaline earth carbonates with ph 7.5 or higher and with ph lower than 7.5. Estimation of amounts of various amendments needed for exchangeable sodium replacement; speed of reaction of amendments and economic considerations; application of amendments.

4. Laboratory and greenhouse tests as aid to diagnosis.
5. Reclamation test in the field.
6. IDENTIFICATION OF RECLAMATION PROJECTS IN AFGHANISTAN

D. Plant response and crop selection for saline and alkaline soils in Afghanistan

1. Significance of indicator plants for saline soils
2. Crop response on saline soils; salinity and water availability; specific ion effects esp. Na, Cl, Bo, bi-carbonates.
3. Crop selection for saline soils: germination; relative salt tolerance of crop plants; relative boron tolerance of crop plants.

E. Quality of Irrigation Water

1. Characteristics that determine quality: electrical conductivity; sodium absorption ratio; boron; bicarbonate.
2. Typical waters
3. Classification of irrigation waters: salinity; alkalinity; diagrams for classifying irrigation waters on conductivity and sodium: effect of boron concentration on quality; effect of bicarbonate ion concentration on quality.
4. Additional water for leaching: It is the extra amount of water that must be applied and percolate through the active root zone to prevent excessive accumulation of salts. It is calculated through the equation: $LR = \frac{ECw}{ECdw} \times 100$

   where ECw is the electrical conductivity of irrigation water and ECdw is the electrical conductivity of drainage water. LR is the leaching requirements.

V. WATER QUALITY

A. Introduction

Apart from the quantity of water and its effect upon the agricultural development in Afghanistan, the quality of water plays a very decisive role. Water quality has an effect upon soils and crops, and on the management that may be necessary to control or compensate for the water quality related problems.

In Afghanistan, downstream water from the different rivers, or that which is pumped out of wells from under the ground is never pure and always contains measurable quantities of soluble salts. In some cases these excessive salts have proven harmful.

Soils and crops are affected in different ways by the different kinds of salts in the water. A periodic water analysis is needed to determine what types of salts are present. Then these must be evaluated in terms of their expected impact upon the soils and crops.

Water analysis should include measurements of total soluble salts by means of electrical conductivity, sodium, calcium and magnesium, chloride, sulphate, carbonate and bicarbonates, and other specific constituents such as boron, nitrates, iron and ammonia.

B. Evaluation of Water Quality

The interpretation of the water analysis can be made to cover these problem areas.

1. Total Salinity: This is caused by the total soluble salts and is measured by electrical conductivity. Total salts have a direct effect upon crops.

2. Permeability effect: This is measured by comparing the relative quantity of the sodium present in the water to the calcium and magnesium. Poor permeability makes it more difficult to supply crops with the water needed for good cropping. It also adds to the waterlogging, salinity, weed and nutrition problems. It should be remembered that carbonates and bicarbonates play a role in permeability status.

3. Toxicity of Specific Ions: Boron, chloride and sodium are the most common ions known to have direct toxic effects on crop growth.

4. Other Problems: These include the increase of acidity or alkalinity of the water, and vigorous growth due to excessive nitrogen, etc.

C. Guideline for Quality Interpretation for Irrigation Water

In this guideline, three areas are recognized, no problem, increasing problem and severe problem areas.

SALINITY			
EC of irrigation water	0.75	0.75 - 3.0	3.0
PERMEABILITY			
EC of irrigation water	0.5	0.5	0.2
adj SAR*	6.0	6.0 - 9.0	9.0
SPECIFIC ION TOXICITY			
From Root Absorption			
Sodium (adj SAR)	3.0	3.0 - 9.0	9.0
Chloride meq/L	4.0	4.0 - 10.0	10.0
mg/L or ppm	142	142 - 355	355
Boron mg/L or ppm	0.5	0.5 - 2.0	2.0 - 10.0
MISCELLANEOUS			
NH_4 - N mg/L or ppm	5.0	5.0 - 30.0	30.0
NO_3 - N for sensitive crops			
HCO_3 meq/L	1.5	1.5 - 8.5	8.5
mg/L or ppm	90	90 - 520	520
PH	normal	6.5 - 8.4	-

*adj SAR = $\frac{Na}{\frac{Ca + Mg}{2}}$ [1 + (8.4 . pHC)] analysis should be in meq/L

D. Salinity Problems

There are two types. The first deals with the salinity of the applied irrigation water and its rapid and direct effect upon crops. The second concerns the salinity that may develop in the root zone over a longer period of time due to accumulation of salts, and its effect upon the crop.

The salinity accumulating in the root zone can be controlled within limits by the application of extra water described as the leaching requirement. However, if the salinity of the applied water is excessive and exceeds the tolerance of the crop, a full potential yield is not to be expected.

High water tables complicate salinity problems. Extra water is used for leaching the excessive salts and good drainage is needed to assure that leaching is effective. Changing a crop to another with a higher degree of tolerance may sometimes prove necessary.

E. Crops Role in Controlling Salinity

Crops have different degrees of tolerance to salts in both water and soils. One of the management alternatives to reduce salinity is to choose a tolerant crop. A given degree of salinity in water may be detrimental to sensitive crops while it may not be so for semi-sensitive, or tolerant crops.

There are tables available which classify crops and their degrees of tolerance to the soil salinity and water salinity to which they can be exposed. Similar tables are made for vegetable, forage and fruit crops.

Tables R-1, R-2 and schematics S1 and S3 are relevant in this connection.

F. Additional Water for Leaching

It is sometimes necessary to apply more water for leaching in order to control salinity. The minimum amount of this extra water that must percolate through the active root zone to prevent excessive accumulation of salts is known as the leaching requirement (LR). This fraction of water is an extra addition to the water supplied to meet the crop water requirements. Leaching requirement can be calculated from the equation:

$$\frac{ECW}{ECdW} \times 100$$

Where ECW is the specific salinity of irrigation water and ECdW is the specific salinity of the drainage water at the root zone.

Laboratory results of complete leaching of highly saline - alkali soils is given in Table R3 as an example.

High water tables can cause a recurrence of salinity at a given soil depth; therefore, deep ones are recommended.

VI. LAND DEVELOPMENT

A. Scope and Sequence

The need for adequate and reliable information regarding the soils and water resources of each potential irrigation project is an initial step in Land Development. This requires preliminary soil, water, and drainage surveys which accumulate the necessary information for long range planning of valley development. Sufficient studies in detail are required as a basis for target estimates.

The basic survey needed usually covers:

1. Soil surveys, reconnaissance or detailed
2. Ground water surveys
3. Drainage studies
4. Hydrologic surveys

Note: Usually detailed surveys follow for the potential projects developed which are from the primary investigation and surveys. For example, detailed soil surveys and soil investigations of certain specific land blocks.

B. The purpose of Surveys and the Reports

These surveys, especially soils, water hydrology, and drainage are presented in maps and tables based on compilation of detailed observations, measurements, and analyses of the land and its associated features; furthermore, they are made and interpreted by the skilled technician in the field for the primary purpose of describing and evaluating the potential use and productivity of a parcel of land and the problems inherent with its development and use.

The conclusions of these broad parameters are to lead to the specific studies related to the development of blocks of lands which are to be developed following their sequence of priority, as stages of development.

This second stage covers:

1. The relative suitability for present or potential irrigation of each soil and soil condition mapped (Land classed as presently irrigable; irrigable when put under cultivation or reclaimed; not suitable; or not recommended for irrigation; and the potential low capability classification).

2. The kinds of limitations and relative degrees of intensity of problems to be overcome in developing and using the land salts, alkali, wetness, levelling,.

erodibility, flood hazard, soil behavior under irrigation.

3. The best suited crops and sequences of crops for each major group of soils and soil conditions.

4. The crop and soil water requirements (soil properties affecting irrigation) lay out crop use affecting delivery of moisture and nutrients requirements.

5. The relative economics of development and use (estimated development costs, gross and net returns and benefit/cost ratios).

C. Presentation and Reporting

Usually this information is presented in a summary volume and other specific subject matter volumes and appendices to cover the loge for pits, laboratory data, etc. There might be specific and supplemental reports to cover the use of the working data available to a specific area. These supplemental reports also have appendices to them to cover the specific legends, soil profile and pit loge, deep or shallow, laboratory analyses, infiltration or leaching trials (in case of salinity) and previous preliminary or interim reports. Map follows containing the soils and drainage surveys and interpetation or classification maps for the use in project development are included. Sometimes the general and supplemental reports are only made for distribution and the rest are kept for the use by the specialized agency.

D. Land Development Classification Usually Covers the following features as a minimum:

1. Physiography:
   Climate
   Native vegetation
   Land use and agriculture
   Topography and drainage

2. Water Resources:
   Surface water sources and their quantities
   The hydraulic micro systems and the micro systems within each
   Quality of waters used for irrigation from the different sources (surface or underground)
   Any relevant data such as degree of efficient use, losses, distribution, etc.

3. Soil Resources:

Soil surveys - degrees, how they are made, their use and interpretations
Main characteristics of the land, origin and development of the soils, principal physical and chemical characteristics.
Main factors affecting development.

E. Specific Features and/or treatments relevant to development potential:

1. Land clearing and levelling
2. Drainage
3. Reclamation treatments
4. Management of different soils (good, soils needing special treatment, etc.)
5. Wind control
6. Erosion, its severity and control.
7. Flood, its severity and control

F. Relative requirements for the development of Land:

1. Crops
2. Water
   - Requirements for different crops
   - Plant growth habits affecting water use
   - Crop rotations and practices to affect water use
   - Water requirements of crops to be grown in the area
3. Fertilizer requirements

G. Relative requirements affecting future development of land:

1. Tillage and general farming practice
2. Water management, its present use and remedial measures and adaptation of different soils

H. Potential Agricultural Development and project selection criteria:

1. Estimates of past and present and expected production
2. Summary of presently irrigated and potentially irrigable lands.
3. Their costs of development
4. Cost/benefit ratio and the potential of development, development stages, production potential and crop values
5. Overall development cost and production potentials

I. Summary and Recommendations

1. Over all
2. Specific stages and sub-projects

VII SOIL CAPABILITY CLASSIFICATION

This project is needed for the country since this basic information does not exist with respect to land as a resource identity. It will answer the relative value of the land when either considered or put under cultivation. It will also clarify the suitability of the different lands when put under cultivation. No meaningful surface irrigation or underground exploration, hydraulogic development without the understanding of the soils.aspects, their capability and suitability, can be had..

Requirements:

Tools, equipment, supplies, technical assistance, institutional development, landsats, laboratory glassware, equipment and chemicals.

The present number of personnel is not adequate for an expanded program of soil survey.

Establishment of a cartographic unit and photo interpretation unit.

Training abroad for short course in soil survey aspects and photo interpretation and cartography. (Dry desertic and mountainous localities - institutions)

VIII. SOIL LABORATORIES AND REQUIREMENTS

A. Soil Laboratories

Two soil laboratories were visited. One belongs to the Ministry of Agriculture and the other belongs to the Ministry of Water and Power. They were once one laboratory, established by FAO in 1960, but were later split into two small ineffective ones. The portion that went to the Ministry of Agriculturedeals with a few analyses and is more oriented to fertility determination and plant food analyses, while the other which is left with the Ministry of Water and Power deals mainly with such water analyses as soluble salts, etc. Both labs need strengthening with respect to chemicals, glassware and apparatices in order to make a complete soil analysis, tests for water, fertility, nutrient difficiences or plant feeding tests. The work is paralyzed by the lack of a centrifuge, soil shakers, suction filtering units, hydrometers, boron free glassware, salinity meters, chemicals and indicators. Kjeldahl flasks for nitrogen determinations are finger counted.

The laboratory personnel have adequate capabilities for their present activities, but future plans for complete analyses and quality data would necessitate training of the presentstaff and an adequate interpretation of the data has not been done. Irrigation projects are therefore reliant on empirical consumptive use data and not on infiltration rates, permeability of subsurface, soil texture and soil response to irrigation. Underground water investigation and digging wells are done without any soil analyses. The only laboratory effective data is the partial analyses related to the quality of water and it total salts.

Neither one of the laboratories is oriented toward salinity or alkalinity problems and its interpretation. The results of any analyses are listed as requested on a common sheet without any interpretation. In this respect a new salinty laboratory is highly recommended. More than half of the cultivated land has this problem and no governmental division, laboratory, or personnel deals with that serious subject at present. A highly qualified expert to assist, train and organize the personnel would be of great value.

B. Requirements

With respect to the laboratory of the Ministry of Agriculture, at least the following should be covered:

1. The stress has to be oriented to physico-chemical aspects of soil properties of Afghanistan with minor localized surveys including the fertility status of the soils.

2. Projects related to soil water and soil fertility in relation to crop production:

   a. To study the effects of different sources of phosphate fertilizers on through uptake of phosphorous

   b. The fixation and release of phosphate in the different soils when applied from different sources

   c. The study of the residual effect of fertilization, and the study of the effect of the addition of organic matter on the rate of phosphate release from the soils, and its availability.

   d. The study of water use patterns by crops nutrient uptake by crops, growth and yield of crops, water and fertilizer uses by crops

   e. The study of tillage in relation to crop productivity and the effect of tillage on water storage in soils.

3. Surveys and status of macro nutrients and certain micro nutrients from specific soils and orchards, and the amelioration of the micronutrient deficiency in fruit crops.

4. Soil test crop response correlation studies including the correlation between different soil tests with respect to N & P & K and the yield of the crop and the recommendation of fertilizer rates based on soil test values.

5. Experiments to establish the most suited crops to the different soils and regions of Afghanistan and the most suitable crop rotation in relation to nutrient requirements and irrigation.

6. A final soil productivity index for different zones should be achieved.

The lab should establish guidelines and give recommendations in soil/water and plant analyses and issue the required certificates. Reports on special forms for all requests should be issued with the qualified interpretations and the suitable recommendations.

Table A2 - 1 CLASSES OF SURVEY AREAS IN AFGHANISTAN IN 1000 HECTARES by FAO Team in 1963

CLASS I	CLASS II		CLASS III		CLASS IV		CLASS V		CLASS VI	
	U	D	U	D	U	D	U	D	U	D
None	181.8	77.3	138.1	176.7	61.4	38.0	252.0	23.6	157.5	68.0
	70%	30%	44%	56%	62%	38%	91%	9%	70%	30%
TOTAL	259.1		314.8		99.4		275.6		225.5	
	22%		28%		8%		23%		19%	

GRAND TOTAL AREA surveyed in the country - 1173.4

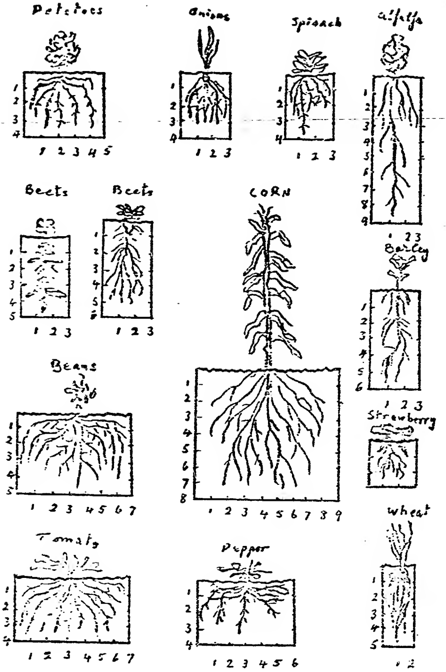
Total Undifferentiated areas	790.8	67%
Total Differentiated areas	382.6	33%

KEY: U = Undifferentiated
D = Differentiated

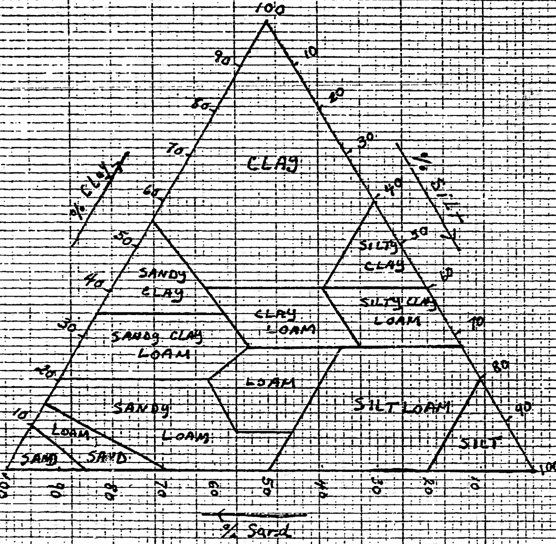
Table A2 - 2 TOTAL AREAS IN CLASSES AND SUB-CLASSES OF LIMITATION

	II	III	IV	V	VI
Total Undifferentiated	181,830	138,045	61,415	252,410	157,450
Total Differentiated	77,300	176,665	38,150	23,600	68,000
(Soil Sub-Classes)					
	S 43,200	S 57,475	S 2,300	SA 600	ST 68,000
	ST 10,000	ST 63,800	ST 25,580	A 14,000	
	SW 2,300	SW 3,000	A 10,000	AW 9,000	
	SA 7,600	A 23,600			
	STA 14,200	AW 10,900			
		W 13,350			
		T 4,450			
Total S	77,300	124,275	28,150	600	68,000
Total A&W	24,100	50,850	10,000	23,600	
Total T	24,200	68,340	25,850		68,000

KEY: S = Soil Texture; A = Salinity; W = Wetness; T = Topography/erosion

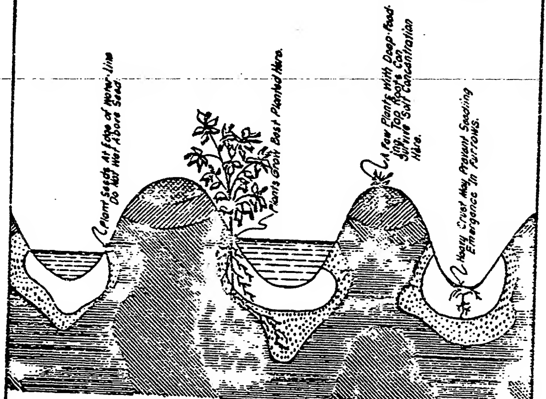


S-1 Schematic Diagram for Root system Distribution
Ref. USDA-SCS H.B. NH. Eng. Soil Conservation
Bullet. #15 - 1959



S-2 Basic Triangle used in soil classification of soil separates

BED AND FURROW IRRIGATION OF SALINE SOILS



AN ILLUSTRATION OF SALT MOVEMENT IN IRRIGATED RIDGES & FURROWS

- Very High Salt $Ec \times 10^3$ = 50+ - No Plants Will Grow.
- High Salt $Ec \times 10^3$ = 15 - 50 A Few Highly Tolerant Plants Will Grow.
- Mod. High Salt $Ec \times 10^3$ = 8 - 15 Tolerant Plants Will Grow.
- Mod. Salt $Ec \times 10^3$ = 4 - 8 Most Common Crops Will Grow.
- Low Salt $Ec \times 10^3$ = 1 - 4 All But Most Sensitive Crops Do Well.
- Very Low Salt $Ec \times 10^3$ = < 1 - All Crops Will Grow Well.

5-3

J-4

ABSTARCTED BY:
Dr. M. RADWAN
US AID CONSULTANT

APPROACH TO LAND DEVELOPMENT.
AS AN ECOSYSTEM
IN AFGHANISTAN

PREREQUISTE: 1- Ag. Development
2- Land Inventory
3- Groundwater Inventory, Quantity, Location, Quality

			Problems
27%	ERODDL.	✓✓	St., Top Erosion SAL
16%	F.D.L.	\\\\\\\\	St. Top Erosion SAL
43%	PAST.L	^^^	St. Top Erosion
7%	IRR.L.	//////	St.
4%	SALTYL.	▭	SAL.

No Drainage or flooding problems.

May 9t: Agr. fertility, root zone depth

ANNEX 3

NATIONAL WATER RESOURCES COMMISSION

The Commission could comprise a Coordinating Board responsible for water policy and water law; its Chairman would be the Minister of Planning or his designated representative. The members of the Board could be representatives of the Ministries of Agriculture and Water and Power; the Rural Development Department; and the Agricultural Bank. A Directorate-General would be responsible for the implementation of policy, and under him would be three Assistant Directorates, each headed by an Assistant Director as follows:

- Investigations and Planning: This branch would be responsible for the inventory and classification of surface waters and groundwaters; the investigation of surface waters through an upgraded hydrometeorological network; and comparable investigations for groundwater sources, including karezes and springs, through drilling and pumping exploration programs.

  Attached to the Investigations and Planning branch would be a National Hydrologic Institute, which would be an operational organization responsible for hydrologic research, surveys, and data collection, and for making such information readily available

to agencies concerned with water development and management.

- Water Resources Development: This branch would be responsible for investigating more efficient means of developing water resources and preparing programs for implementation, such as the artificial recharge of developed groundwater resources, enlargement of water intercept areas such as infiltration galleries, or the feasibility of runoff irrigation insofar as water resources were concerned.

- Conservation and Management: Attached to this branch would be a National Water Resources Control Agency which would be responsible for overseeing the apportionment of all water in "declared" groundwater basins, the allocation of surface water supplies, the adjudication of water disputes, the licensing of well drillers and the issuance of permits for well construction, and other conservation and management functions as deemed desirable by the Coordinating Board.

ANNEX 4. DETAILS OF METHODOLOGY USED IN REPORT

INTRODUCTION

The methodology used in this assessment of irrigated agriculture in Afghanistan may be separated into the following five stages, which are described in detail in subsequent paragraphs.

- Data-gathering
- System analysis
- Problem identification
- Problem-solving
- Identification of potential programs

1. Data-gathering

The team reviewed the literature, was briefed by USAID and DRA officials and outside experts, and then made field trips to selected locations in Afghanistan to study different types of irrigation systems. The objective was to learn as much as possible about the various facets and complexities of all relevant details of irrigated agriculture in Afghanistan.

2. System analysis

The system was then separated into sub-systems and key variables. The major concern (and the dependent variable for further study) was the

utilization of irrigation water. A supply system and a demand system, for a representative on-farm irrigation system was then developed, each consisting of a number of independent variables which affected the utilization of irrigation water. Some eleven key variables (six for the supply system and five for the demand) were identified, each with numerous sub-variables. These were plotted on the diagram shown on Table I-1. Subsequent analysis led to the determination of interrelationships between two or more key variables and other sub-variables - or other key variables. These linkages were sketched in the form of a diagram of interrelated ovals, which is shown on Table A4.1.

The joint USAID-Experience, Incorporated Team then met with representatives of irrigation-related DRA ministries to discuss current progress and findings; solicit suggestions and criticisms; and in general obtain a consensus that the Study was proceeding correctly. The DRA participation was of assistance in assigning some priority to the key variables, e.g., the conclusion that the major problem affecting conveyance systems was seepage losses.

3. Problem Identification

The next step in the methodology was the refinement of problem identification. Following a number of discussions, three discrete problem areas were abstracted from the aforementioned eleven variables, as

follows:

a. Resources (basically a failure to optimize);

b. Conveyance systems; and

c. Utilization.

4. Problem Solving

The fourth phase of the assessment was the development of possible solutions that would be responsive to the problem areas identified during the third stage. In subsequent group discussions a number of alternative solutions were proposed to ameliorate or correct these problems. No evaluation of the particular merits or feasibility of any particular solution was attempted at that time: the intent was to minimize any extended discussion which might have hindered the free flow of ideas. A smaller sub-group then met to discuss the various solutions in more detail. At this time, less-reasonable solutions were deleted, related ones were combined, and certain others were elaborated upon and refined. The result of this discussion was the Problem-Solution Matrix presented in Table A 4.2. This matrix constituted the agenda for the team's second general meeting with DRA officials; at this meeting the solutions developed by the team were presented to the DRA for their comments and criticism. An attempt was also made to assign priority and weight to the solutions offered. While this tactic did not prove too successful, given the varying

interests of the DRA officials present, the general agreement expressed was that the majority of the solutions offered by the Team were responsive to the identified problem areas.

5. Identification of potential programs ("packages")

In this last stage of the assessment each possible solution was first evaluated against several feasibility criteria which reflected USAID project soundness concerns (See Table A 4-3).

However, these criteria were found to be ineffective in fully screening some of these solutions, a situation which might be accounted for as reflecting certain prior (albeit unintentional) screening to which the solutions had been subjected in the process of formulation during the group discussion sessions. Indeed, the majority of the solutions were not affected by the feasibility criteria screening.

It was then decided to proceed to an indexing exercise to identify and label those solution elements which affected

a. The farmer directly through his land; his irrigation supply; his farming practices; and any other activity relevant to on-farm irrigated agriculture;

b. The common interests of the farming community;

c. The nationwide interests of the Government in supporting the

development of irrigated agriculture; and

d. The financial implications with respect to foreseen needs for technical assistance, training, commodities, equipment, and program funding.

The indexing exercise culminated in the recombination of solution alternatives into seven technical packages and one policy package. This packaging was then discussed with DRA officials, during the course of which their opinions were solicited and received concerning the nature of the required inputs of technical assistance, commodities, equipment and the types of funding. Their views on the Ministries and departments who might be involved if any of these packages were to be implemented, were also obtained. Additionally, the following views were given by the DRA officials:

1. As most of the packages would require more than one agency for implementation, there should be closer coordination and linkage between them. This can be effected through an inter-agency protocol.

2. Implementation of systems could be allocated among interested agencies in accordance with project size as follows:

- Large scale systems: Ministry of Water and Power
- Average or small systems: Rural Development Dept.
- Individual structures: Farmer himself through credit

from the Agricultural Bank and by acquiring the technical skill from the Rural Development Department.

Agricultural Bank is prepared to finance technically sound projects by receiving advice from the Rural Development Department and the Ministry of Water and Power.

As Afghanistan is a progressive country, foreign training would be required for practically all of the packages.

Demonstration projects would be very useful and should be given important consideration in the relevant packages.

Relationships in Small-Scale Irrigation

Table A-4.1

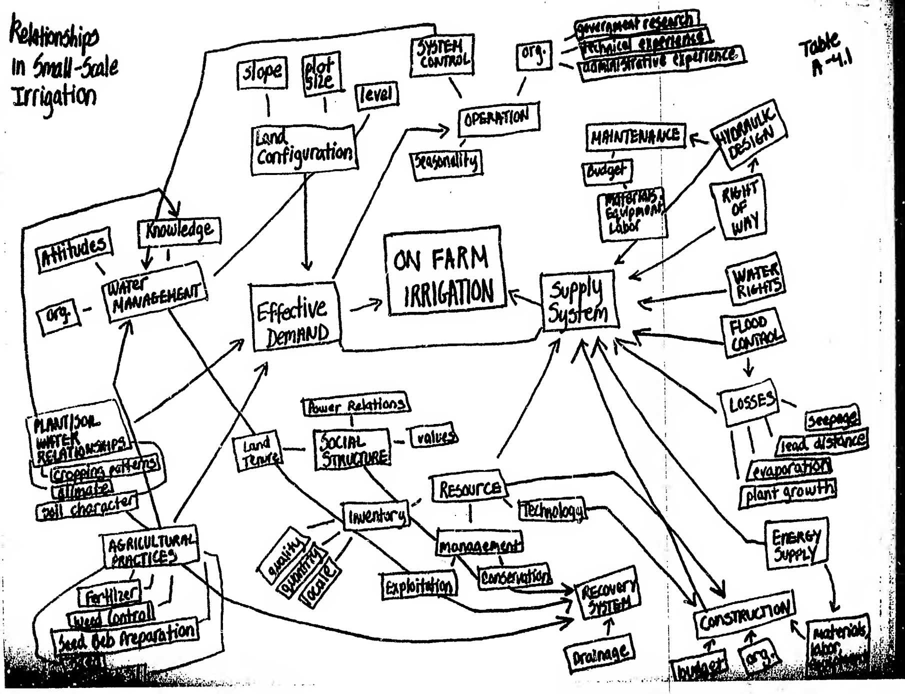


Table A-4.2

IRRIGATION SUB-SECTOR ASSESSMENT: Alternative Solutions

Introduction.

Problems. Problems can be grouped under 3 headings: Problems Involving the Failure to Optimize Water Resources, Problems with the Conveyance System, and Problems regarding the Utilization of Irrigation Water on the Farmer's Field.

Solutions. Solutions to these problems are outlined below. It should be emphasized that the solutions are but possible alternative solutions. Before an actual project may be developed, each of these alternative solutions will have to be subjected to technical, economic, and social analysis to determine their feasibility.

PROBLEM	POSSIBLE ALTERNATIVE SOLUTIONS
1. Resources	
A. Lack of knowledge of quantity and quality of resources and how to effectively utilize them.	1. Inventory and classify soils, surface water, and ground water. 2. Begin immediate ground water exploration. 3. Establish Water Resources Commission, responsible for water policy, water law, allocation, etc.
B. Underground water is an unknown entity; what is now being used is in danger of depletion; and the traditional systems of exploitation need upgrading.	1. Begin Underground Water development program . 2. Undertake artificial recharge of developed ground water resources. 3. Undertake investigation for further development of karez, particularly on: a. Storage of wastewater underground b. Enlargement of water intercept areas. 4. Undertake investigation for further development and utilization of springs. 5. Construct Infiltration Galleries.
C. Surface water Needs to be monitored, conserved, and augmented if possible.	1. Up-Grade Hydro-Meteorological Networks 2. Construct Surface Storage Reservoirs a. on both perennial and non-perennial streams b. off-stream

PROBLEM	POSSIBLE ALTERNATIVE SOLUTIONS
1. Resources, cont'd.	3. Undertake a Soil and Water Conservation Program a. Impose control on Resource ar b. Vegetative Practices c. Mechanical Practices 4. Investigate possibilities of implementing a cloud-seeding program. 5. Utilize wells to augment surface supply where feasible. a. Battery of shallow wells b. Deep wells
2. Conveyance Systems	
A. Current diversion structures need to be improved and other means of capturing water need to be investigated.	1. Up-Grade current diversion structures a. Make indigenous structures semi-permanent (gabions) b. Make indigenous structures permanent 2. Utilize alternative lift methods (for example, pumps & motors). 3. Relocate diversions 4. Impose controls on flow of water in karez systems. 5. Store karez water at exit. 6. Utilize run-off irrigation. 7. Combine diversion structures.
B. Seepage within the conveyance system is the chief cause of loss and inefficiency.	1. Line canals at selective points in the conveyance system. 2. Over-design canals to off-set seepages. 3. View seepage as a re-charge to groundwater, and dig wells to tap that groundwater. 4. Shorten lead canals a. Design & construct more permanent diversions. b. Pump water from river directly into canal. 5. Improve maintenance on irrigation system a. Aquatic control b. Weed control c. Silt Removal

PROBLEM	POSSIBLE ALTERNATIVE SOLUTIONS
2. Conveyance Systems, cont'd.	
C. Flood protection is generally inadequate, and this results in major losses in the conveyance system.	1. Construct Headgate control structures. 2. Install siphons (where irrigation canal goes under wash-crossings). 3. Construct flumes (where Irrigation canal goes over a wash-crossing). 4. Build "cut and cover" structures where canal passes across a wash-crossing or where it passes along the sides of hills and cliffs and is subjected to rock or land slides. 5. Construct diversion channels, guide levees, or dikes. 6. Build sluiceways. 7. Buttress or support canal banks.
D. Physical structures for controlling water-flow in the conveyance system are lacking or in need of improvement.	1. Install division boxes. 2. Construct checks. 3. Install turnouts. 4. Construct drop-structures. 5. Install metered gate structures. 6. Utilize concrete pipe and close the system.
E. The social organization of water control and distribution needs improvement.	1. Establish a training program for Mirabs and their assistants (chakhbashi). 2. Institute inspection and supervision of mirab/chakhbashi operations. 3. Establish standards for operation and maintenance of irrigation systems. 4. Formulate water laws.
3. Utilization.	
A. Lack of Knowledge by farmer & technician of efficient water-use practices.	1. Begin research on proper water application rates, based upon local soil/water/plant relationships. 2. Develop and disseminate Irrigation Guidelines. 3. Institute on-farm training courses in water management and water-use principles, utilizing:

B.

4. Marketing infrastructure is sufficiently in-place that increased production, thru irrigation improvement will lead to increased farmer income.

C. Social.

1. The project will benefit rural poor.

2. The project has the potential to spread to other, non-primary, beneficiaries.

3. The project is compatible with the local social structue and cultural values, i.e., there will be no adverse socio-cultural impact.

4. Villagers are likely to participate in design, plan, implementation, and maintenance of project.

D. Political.

1. DRA willing to make needed policy changes to insure project success.

2. Irrigation-related ministries and agencies willing to cooperate in design, planning, and implementation of the project.

3. The proposed project is compatible with DRA current 5-year Plan.

4. The project's design package and funding is acceptable to DRA.

5.

E. Environmental

1. No adverse environmental impact is foreseen.

Addendum. One can of course view all of the alternative solutions as equally important, opting then for a number of different but simultaneously applied development packages or sub-projects within a larger design. For example, one component could be the soil and water inventory, another could be the investigations of further development of springs and karezes; at the same time an immediate program of groundwater exploration could begin; and a third package could consist of improvements to CIS structures (diversions, conveyance structures, etc.), mirab training, and on-farm water management training programs (working mainly through demonstrations).

Each of these components could be expanded and sketched in greater detail. They are offered here as an alternative to choosing among various but equally desirable alternatives. A further advantage of the component or package approach is that it regroups the variables into a system, recognizing that we are dealing with a system and that all the parts are inter-related; thus, the best solution is one which deals effectively with sub-systems within that larger system.

PROBLEM	POSSIBLE ALTERNATIVE SOLUTIONS
3. Utilization, cont'd.	a. Demonstration plots b. Class instruction 4. Establish an in-service training program for sub-professionals, technicians and especially extension workers.
B. On-Farm Infrastructure related to water-use efficiency is lacking or in need of improvement.	1. Improve on-farm distribution systems, by utilizing: a. Spiles, siphon tubes b. Tile channels and drains c. Brick/concrete turnouts (pre-fab turno 2. Undertake a program for leveling farmers fields. 3. Improve on-farm drainage 4. Dig on-farm wells to augment water supply during droughts.
C. A soil improvement program related to water-use is urgently needed.	1. Undertake Land/Soil Improvement Program a. Increase fertility levels 1) fertilization 2) soil amendments b. Reclamation of soil c. Sub-soiling
D. Current farming practices are not conducive to efficient water-use.	1. Improve Cropping System a. Crop rotation (including fallowing) b. Inter-cropping 2. Introduce agricultural practices which will result in greater water-use efficiency. a. Weeding b. Proper seeding c. Proper fertilizer application d. " Land preparation
E. Runoff Irrigation	

Table A-4.3

Irrigation Sub-Sector Assessment:
Phase IV: Evaluation of Alternative Technical Interventions.

Introduction: The numerous alternative solutions derived from our brain-storming session and subsequently refined in meetings among ourselves and in conjunction with our DRA counterparts have now to be evaluated. One objective method for doing this is to set forth a number of criteria against which each of the alternative solutions can be measured. Those solutions which cannot meet all the criteria are given a lower priority in the final recommendation phase, while those which do pass muster against the criteria will likely evolve into full-fledged projects later on.

In USAID project Paper Documentation, each project must be analyzed in terms of its technical, economic/financial, and social soundness. For discussion purposes for today's meeting, we have decided to search for distinct criteria within that USAID Project Paper Format. After discussion, of course, we may refine this framework or indeed decide upon other, more relevant, criteria. Presented below, then, is a tentative evaluation schema for discussion.

ANALYSES	FEASIBILITY CRITERIA
A. Technical.	1. Institutional capability to implement the project is available or readily developed thru budget and technical assistance (this includes both governmental and local capabilities).
	2. The technical intervention itself is is technically sound.
	3. The solution offered can utilize appr[illegible] technology (i.e., local expertize, m[illegible] labor).
	4. Local, governmental, and foreign contribu[illegible]tions can be expected.
B. Economic/Financial.	1. Villagers' have capacity to contribute financially to project.
	2. Benefit-Cost Ratios are favorable (1[illegible])
	3. DRA willing to commit funds, material, and personnel to effect project success.

ON-FARM TECHNICAL PACKAGES (Preliminary) Table A-4.4

I. INVENTORY

Inventory and classify soils, surface water, and ground water. This includes upgrading of soils laboratories, hydrometeorological network, and the capability for making ground water explorations.

II. SYSTEM INFRASTRUCTURE

1. Upgrade diversions
2. Lift method of diversions
3. Relocate diversions
4. Controls on Karez
5. Combine diversion
6. Canal lining
7. Shorten lead canal
8. All of flood protection
9. All of Water Control Structures
10. O&M

III. ON-FARM INFRASTRUCTURE

1. All of on-farm infrastructure
2. On-farm wells

IV. SOIL IMPROVEMENT PROGRAM

1. Soil reclamation
2. Soil Productivity Improvement

V. RESEARCH

1. Soil/water/plant relationship
2. Irrigation Guides
3. Drainage Guides
4. Runoff Irrigation
5. Cropping Systems
6. Cultural practices including Varietal Testing

VI. EXTENSION AND TRAINING

1. In-Service Training Program
2. Farmer Training Courses
   a. Farming Practices
   b. Soil Management Practices
   c. Water Use Practices

VII. GROUNDWATER DEVELOPMENT

1. Wells
2. Springs
3. Karezes
4. Galleries
5. Artificial Recharge
6. Groundwater testing

Pkgs.	TA	TNG	Supply/ Equip.	Funding		
				Cr.	FAR	Dem.
I.						
II.						
III.						
IV.						
V.						
VI.						
VII.						